DISEASES OF THE EAR.

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DISEASES OF THE EAR:

FOR

PRACTITIONERS AND STUDENTS OF MEDICINE.

BY

JAMES KERR LOVE, M.D.,

Aural Surgeon, Glasgow Royal Infirmary; Lecturer in Aural Surgery, St. Mungo's College, Glasgow; Aurist to Glasgow Institution for the Education of the Deaf and Dumb.
Author of "Deaf-Mutism."

WITH FIFTY-FOUR STEREOSCOPIC PHOTOGRAPHS;
TWO COLOURED PLATES, AND MANY ILLUSTRATIONS.

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PREFACE.

WHEN a period of rapid development or sudden transition overtakes a branch of knowledge, one result is the appearance of new works on the subject. Such a development and transition has overtaken Otology within recent years. The modern treatment of middle-ear suppuration and its complications has thrown a responsibility on the general practitioner, and demands a knowledge of operative detail on the part of the aural surgeon which was not dreamt of fifteen years ago. The chief objects of this work are to spread a sense of that responsibility and knowledge. These objects could not be attained without carrying the practitioner back to his student days and asking him to make once again a serious study of the anatomy of the temporal bone. That the writer is not wanting in a sympathetic recognition of the difficulties of that study is made clear by the fact that he has called to his aid stereoscopic photography—perhaps a new departure in a book on diseases of the ear.

Suppurative ear disease has been discussed at considerable length—at greater length than was possible with other departments of the subject were the book to be kept of reasonable size. A chapter of moderate size has been given to Deaf-Mutism, because this subject seems to the author to be treated in similar text books with too much brevity, and because he has had occasion to make a long study of this department of Otology. The portion of this chapter which deals with the delimitation of the residual hearing of Deaf Mutes is part of a Research conducted under the auspices of the Carnegie Trust, for the Universities of Scotland.

The work is a record of personal experiences. No attempt has been made to add a Bibliography, but due credit has been given to those who are contributing to the advancement of Otology.

The stereograms are placed together at the end of the work, and, wherever necessary, are accompanied by explanatory keys. They form a separate anatomical study, though their chief objects are to render the text clear, and to make involved anatomical description unnecessary. The reader is recommended to examine these pictures carefully before beginning the text of the work. The stereograms are the work of the writer and of his assistant and friend, Dr. John W. Leitch, to whom he takes this opportunity of returning his thanks. Dr. Leitch has also with great kindness revised the proofs and written the Index. With the exception of the Hunterian specimens, almost all the specimens from which the stereograms are taken have been made by the author, who desires to acknowledge his indebtedness to Dr. J. H. Teacher, and the Senate of the University of Glasgow, for liberty to photograph and publish William Hunter's specimens.

It gives the author great pleasure to acknowledge the uniform courtesy which has been displayed towards himself, and the great care which has been bestowed on the work by the publishers, Messrs. John Wright & Co.

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DISEASES OF THE EAR.

CHAPTER I.

INTRODUCTION.

THE position of Aural Surgery at the present time is one of great interest. Like all other departments of surgery, it has been revolutionized, or at least profoundly influenced, by the greatly extended use of anæsthetics and by the application to its practice of the principles of asepsis. But it has not kept pace with the advance in other departments of surgery. The abdomen and the thorax are opened with a thoroughness and a readiness which is not yet adopted in dealing with the temporal bone. Operations in the former cavities are made in anticipation of the formation of pus; most surgeons only think of opening the cavities of the temporal bone when pus, the existence of which has been strongly suspected or actually known, threatens the patient with intra-cranial symptoms.

This difference of practice is not due to any lack of enthusiasm or of ability on the part of aural surgeons. The reason for it is found in the involved anatomy of the temporal bone itself. There is no structure in the body the anatomy of which is so difficult to understand as that of the temporal bone, and there is none for the study of which the student is so badly provided with means and illustrations.

Nevertheless, progress in dealing with the suppurative changes occurring within this bone has, during the last fifteen years, been very great. Before that time authors contented themselves with the statement that under certain circumstances the mastoid process

should be opened—that it was safe and justifiable to open it. Few cases of intra-cranial abscess, the result of middle-ear disease, had been dealt with, although such cases were commoner then than now. During these fifteen years, by a series of brilliant developments, the operations for intra-cranial abscesses have been perfected, and that for sinus thrombosis has become quite common. Such operations, both by general and aural surgeons, fill the pages of the general and special journals, and successes are so common as to occasion hardly any comment.

But there is much more demanded of aural surgery than this. It is a very striking illustration of skill—this successful hunt for the intra-cranial abscess or other secondary effect of middle-ear suppuration, and I do not wish to detract from the credit due to those great surgeons who have led us to these successful results. But such operations should seldom be necessary. It is quite as brilliant, and a much safer procedure, to operate on the temporal bone whilst the suppurative process is still limited to it; and one of the statements which the author will attempt to prove in this work, is that the diagnosis of the condition referred to is generally possible, and that operative measures should be adopted without waiting for the beginning of intra-cranial complications.

Put broadly, the statement is this :—Every suppuration within the temporal bone can be cured, and the treatment of it must be followed to a finish, even if it involve the opening up of all the cavities within the temporal bone.

There are two requirements which must be fulfilled before the thorough treatment of ear suppuration above indicated can be realized. The first is a greater operative dexterity on the part of the aurist, and the second a more accurate knowledge of the anatomy of the temporal bone on the part of all classes of practitioners. The aurist of the immediate future must be a surgeon also. He cannot longer devolve the more difficult parts of his work on the general surgeon : that is a division of labour which is quite indefensible. The man who is confident about the movements of his chisel within the recesses of the temporal bone is quite capable of dealing with

the secondary effects of middle-ear suppuration within the skull, and of tying the jugular vein. He may begin his operation under the impression that he has only a mastoid abscess to open, but before he finish he may have to split the sinus and tie the jugular in the neck.

Though it be true, however, that the radical treatment by operation of the suppurative processes within the middle ear must always be undertaken by the special surgeon, it is not therefore true, that the study of the anatomy of the bone should be left to him. Cases needing operation are almost all in the hands of the general practitioner for a time, and unless he appreciate the indications for operation—which he cannot do without an accurate knowledge of the anatomy of the bone—he cannot guide his patient safely for a single week.

In the following pages an attempt has been made to render the study of this difficult piece of anatomy easy. Pictures have been made to take the place of tedious description. By stereoscopic photography, the specimen has been made to stand solid before the observer. The substitute is not so good as the actual specimen—no substitute can be—but it is a great advance on any flat drawing. A careful and repeated study of the stereograms used here as illustrations, will do much to make the anatomy of the temporal bone clear. Fortunately for the object the writer has in view, the temporal bone lends itself well to this method of illustration—perhaps better than does any other part of the human body.

Although the management of suppurative disease within the temporal bone may be looked upon as one of the solved, or almost solved problems of aural surgery, the latter does not lack attraction for want of difficult situations—problems still unsolved. Chronic aural catarrh and oto-sclerosis have long been the stigma of aural surgery. Before them the practitioner stands defeated. Here the quack thrives. Many of the devices used in the treatment of these conditions by specialists are marked by great ingenuity and resource; but the fact that the results attained are seldom great,

and hardly ever uniform, shows that there is yet some lack of appreciation of the real nature of the conditions to be dealt with. One often retires from such cases baffled and disgusted, and only resumes the treatment of the next under the hope that light will come some day. Perhaps we may have to begin all over again with this difficult class of cases: in any event, a careful study of hearing tests must form a part of any solution of them. Under the heading of "Examination of Aural Cases," therefore, a larger consideration of functional tests has been given than perhaps is usual in a work of this size; but it is in the hope that a contribution has been made to the study of a very difficult problem, that the writer has been tempted to be discursive.

No great development has taken place in the study of diseases of the external ear, nor, indeed, is there likely to be any such development. The diseases of the auricle, and to some extent those of the external auditory canal, lie only on the borders of specialism, and the diseased conditions which affect these parts differ much less from similar conditions elsewhere than do the diseased conditions in the middle and internal ears.

The etiology, the diagnosis, and the treatment of diseases of the internal ear are still shrouded in much darkness; but the light is gradually breaking, chiefly by the patient efforts of the pathologist and the bacteriologist, and there will no doubt be great progress chronicled here in the not distant future. The elaboration and better understanding of hearing tests will do much to prepare the way for these results.

The materials for this work have been drawn from two sources: the aural department of the Glasgow Royal Infirmary, and private practice. The latter gives by far the best field for that kind of observation on which inference should be based; for although the number of cases seen is smaller than in the outdoor department of a great hospital, the attendance of the private patient is much more regular and continuous, and the home treatment is much more thoroughly carried out. This is especially the case in the treatment of suppurative disease of the middle ear. No disease

requires more patient or thorough treatment, alike by the patient and the surgeon, and in none is the result more unsatisfactory when the patient is treated at the outdoor department of a hospital or infirmary. On the other hand, the indoor treatment of suppurative middle-ear disease—largely operative of course—is eminently satisfactory. During the last twelve years the writer has had to perform the mastoid operation nearly four hundred times, and the majority of these cases have been within the wards of the Royal Infirmary.

The distribution or incidence of ear disease is not so easily represented as may at first appear. In the private practice of the otologist, the cases are chiefly those which are referred to him by the general practitioner, and are necessarily the serious, the difficult, or even the incurable cases. They cannot therefore be taken as representing the incidence of ear disease. In hospital practice, on the other hand, the patients being for the most part drawn from the poorer classes, the proportion of neglected cases and of chronic suppuration is greater than in other classes of practice. Perhaps the truest percentages would be obtained from the experience of a general practitioner, spread over a large number of years; but there are many reasons why this is not available, or at least seldom given. The best field at the disposal of the writer, for observation as to the incidence of ear disease, is the outdoor department of the Royal Infirmary, and his conclusions have been based on an analysis of the last 630 cases, tabulated on the following page. The table is meant to include only the common forms of ear disease, all really unusual conditions being included in the miscellaneous group. It shows the incidence of ear disease in the poorer classes of a large city. Over a third of the cases presenting themselves for advice at the outdoor department were the subjects of chronic middle-ear suppuration. The acute dangerous complications of this disease hardly appear here, for many of these cases come directly to the wards of the ear department, and to the general surgical wards of the infirmary. Nearly a fourth of the cases had ceruminous or other collections in the external auditory canal.

About a tenth had post-nasal adenoids causing deafness, and about the same number were the subjects of chronic aural catarrh, a disease which in the better classes of society figures more largely in the statistics of ear disease. Acute and sub-acute middle-ear inflammations account for about a tenth of the cases. The importance of this group depends not on the actual number of cases, but on the fact that most of the chronic suppurative cases and of the cases of chronic aural catarrh begin as acute middle-ear inflammation.

		Cases.
Eczema of the auricle or external auditory canal		21
Cerumen or other collections in one or both ears ..	123	
Cerumen collection with chronic middle-ear discharge present or absent ..	37	160
Chronic suppurative inflammation in one or both ears ..	189	
Aural polypi complicating chronic middle-ear suppuration ..	14	214
Acute complications complicating chronic middle-ear suppuration	11	
Acute or sub-acute middle-ear inflammations ..		64
Deafness due to post-nasal adenoids ..		55
Chronic aural catarrh and otosclerosis		58
Syphilis (usually of the internal ear)		9
Furuncle of the external auditory canal		9
Otalgia (usually due to diseased teeth) ..		6
Deaf mutism		7
Other cases (miscellaneous)		27
		630

CHAPTER II.

ANATOMY OF THE EAR AND PHYSIOLOGY OF HEARING.

The Divisions of the Organ of Hearing—The External Ear—The Tympanic Membrane—The Anatomy of the Temporal Bone—The Tympanic Cavity and its Contents—The Eustachian Tube—The Facial Nerve, the Lateral Sinus and the Brain in their relationship to the Middle Ear and the Mastoid Process—Blood-vessels and Nerves of the Ear—Pus Channels to Surrounding Structures—The Ear in Children—The Anatomy of the Internal Ear—Sound in its Relation to Hearing—The Physiology of Hearing.

THE EAR or organ of hearing is divided for descriptive purposes into three parts :—

I.—THE EXTERNAL EAR, including the auricle or pinna, and the external auditory canal.

II.—THE MIDDLE EAR or TYMPANUM, containing the auditory ossicles, and communicating behind with the mastoid cells, and in front with the throat by the *Eustachian tube.*

III.—THE INTERNAL EAR or LABYRINTH, containing the cochlea and the semicircular canals.

The external ear and the tympanum are usually called the sound-conducting parts of the organ of hearing; the internal ear being regarded as the sound-perceiving part. In reality a small part of the cochlea only—the *ductus cochleæ*—contains the sound-perceiving arrangements, the rest of the cochlea being sound-conducting. The semicircular canals have nothing to do with hearing; they have to do with equilibration.

I.—THE EXTERNAL EAR.

The external ear is composed of the *pinna* or *auricle,* and the *external auditory canal* (*Stereogram I*). The former is entirely made up of soft tissue, chiefly skin and cartilage; the latter is cartilaginous in its outer, bony in its inner half.

The **Pinna or Auricle** is composed of cartilaginous plates, curved to certain definite outlines (*Stereogram II*). Its external surface is concave. Its free convex border forms the *helix*, and is somewhat rolled inwards on itself, forming the fossa of the helix—a groove parallel with the helix. A small projection in the upper and back part of the helix is known as *Darwin's tubercle*, and is analogous to the tip of the ear in quadrupeds. In front of the fossa of the helix is another ridge passing backwards and downwards, known as the *antihelix*, and within the upper part of the curve of this latter is a second curved groove called the *scaphoid fossa*, or fossa of the antihelix. This fossa is filled with effused blood in othæmatoma, or blood-tumour of the auricle. Within the lower part of the curve of the antihelix is the *concha*, the expanded cup-like depression which forms the entrance to the external auditory canal. In front of the concha is the projection known as the *tragus*, and behind it that known as the *antitragus*. Between these projections is the groove of the *incisura intertragica*. The lowest part of the auricle has no cartilage, and is called the *lobule*. Here ear-rings are suspended, from an artificial perforation through the substance of the lobule, and in the perforation thus used, pathological conditions demanding treatment may arise.

Except at one or two gaps on the posterior surface of the auricle, which are filled with fibrous tissue, and are known as the *incisuræ santorini*, the cartilage of the auricle is prolonged as an uninterrupted funnel-shaped process inwards to form the outer part of the external auditory canal, and is fixed, very firmly in front and more loosely behind, by fibrous bands to the outer end of the osseous external auditory canal. Fibrous bands also bind the auricle to the skull—above to the zygoma and behind to the mastoid process. Small intrinsic muscles stretch from one part of the auricle to another. Larger extrinsic muscles stretch from the auricle to the structures on the side of the head. The intrinsic and even the extrinsic muscles are rudimentary and, surgically at least, are unimportant.

The arterial blood supply of the auricle is from the posterior

auricular, the occipital, and the superficial temporal vessels. The first-named is often cut in surgical manipulations about the mastoid process.

The veins of the auricle vary in their distribution, but the return blood ultimately reaches for the most part the external jugular vein, a part of the blood, however, reaching the temporal and internal maxillary veins.

The lymphatics round the auricle lead into the posterior auricular and parotid lymphatic glands. These two sets of glands, the one placed in front of the tragus, the other lying on the mastoid process and over the upper part of the sterno mastoid muscle, often enlarge in connection with irritations of the auricle itself. As the middle-ear lymphatics also lead into these glands, periotic glandular abscesses are common in middle-ear disease, and are very common in tubercular middle-ear disease.

The nerve supply of the auricle is from the auriculo-temporal and the great auricular nerves. *Arnold's nerve,* a branch from the pneumo-gastric, communicates with these; and this connection and the similar connection in the external auditory canal, is supposed to supply the explanation of ear sneezing, ear cough, ear yawning, and ear vomiting, which characterize the presence in some cases of foreign bodies and ceruminous collections in the canal, as well as to account for the habit which some epicures have of touching the back of the ear with the moistened serviette in order to increase gustatory sensations; hence the term "the alderman's nerve" (Treves). The communication of the auriculo-temporal with the superior and inferior maxillary nerves through the fifth, their common origin, explains the pain referred to the ear in affections of the teeth.

The thin cartilaginous plates which form the auricle are covered by skin with hardly any intervening tissue, and the skin and cartilage are so closely and firmly connected that the former hardly moves on the latter.

In the **External Auditory Canal** these conditions are even more marked. Hence it is that boils occurring in the walls of the canal

are extremely painful, great tension resulting from very little swelling. Along the upper and posterior wall of the canal, towards the junction of the cartilaginous and bony parts, the canal is contiguous to the anterior and lower set of mastoid cells; and from these pus sometimes bursts, bulging the roof or back wall, and forming a fistula in the neighbourhood. The skin of the canal is supplied, especially on the posterior wall, with numerous *ceruminous glands*, which secrete the wax of the ear; and near the junction of the canal with the concha are numerous *hair follicles*, from which strong hairs grow (*Stereograms I, X, XI*).

The canal itself is a blind cul-de-sac, with a narrow or waist-like part at the junction of its middle and inner thirds. This waist-like part or isthmus is caused by the convexity upwards of the floor, and the similar convexity backwards of the anterior wall, at the point above indicated. A foreign body at the inner end of the canal may have ample room, but its extraction through this narrow isthmus may be very difficult (*Stereograms I, III, XI*).

The *direction* of the external auditory canal varies, but it is never at right angles to the side of the head. It runs forwards and upwards as well as inwards, towards the membrana tympani; sometimes a probe held in its axis points almost to the shoulder of the patient when the latter looks straight forward. The direction should be ascertained in every case before using the syringe, else the current may be directed against the walls of the canal. The canal is straightened and its direction made nearly at right angles to the side of the head, by pulling the auricle upwards and backwards, a manœuvre very useful during syringing and when using the speculum (*Stereograms I, III, X*).

The external auditory canal, measured from the tragus to the tympanic membrane, is about 1½ inches long, and its inner end is blocked by the tympanic membrane. Because of the oblique position of the membrane, the canal is longer in front than behind, and longer below than above (*Stereograms I, III, X, XVII*).

The **Tympanic Membrane,** which forms the inner end of the external auditory canal, has, as seen through the speculum, an almost uniformly glazed pearl-like look, broken by the whiter line of the handle of the *malleus*, which shines through the membrane and stretches downwards and backwards from the upper and front part of the membrane towards its centre, like the spoke of a wheel (*Stereograms V, VI, VIII*). The chief part of the membrane is concave towards the external auditory canal, and this curve is such that from near the centre, where the malleus handle terminates, there extends downwards and forwards to the border of the membrane a *triangular spot* or cone of light (*Fig.* 1, p. 22). Any change in curve, such as happens when the membrane is in-drawn; any thickening, such as occurs in chronic inflammation of its structure; or any reddening of its surface, such as happens in acute inflammations of its substance, alters these appearances.

The above description of the membrane applies to almost its whole area (*pars tensa*), but there is a small part above and in front (*pars flaccida*, or Shrapnell's membrane) where the appearances are different. Here the short process of the malleus projects in relief as a definite nipple-like body; and extending forwards and backwards, as definite crescentic folds towards the contiguous meatal walls, are the anterior and posterior folds of the tympanic membrane. The triangular portion of membrane between the folds, and extending upwards and forwards to the circumference, is thinner than the rest of the membrane, is less tightly stretched, and is known (as above indicated) as the *pars flaccida*, or Shrapnell's membrane. It fits into the *notch of Rivini*, or that portion of the bony circumference of the membrane where the tympanic ring is imperfect. Internal to this *pars flaccida*, and between the membrane and the ossicles, is a small space, *Prussak's space*, which communicates with the tympanic cavity, but within which cario-necrotic processes affecting the ossicles are apt to originate (*Stereogram XXXVIII*).

Looking at the membrane from the inside (*Stereogram XXIV*) it is seen to be convex towards the middle ear, its centre being

pulled inwards at the umbo by the tip of the malleus handle (*Stereogram III*).

The tympanic membrane is fixed (except at the notch of Rivini) into a groove in the tympanic ring, the *sulcus tympanicus* (*Stereogram XXXII*).

The tympanic membrane consists of three layers; one derived from the external auditory canal—a *cutaneous layer;* one derived from the middle ear—a *mucous layer;* and a *fibrous layer* between the two. The fibrous layer consists of two lamellæ: one external, and with its fibres *radiating* in direction, and one internal, with its fibres *circular* in direction. The radial fibres are most numerous, and extend from the handle of the malleus (*umbo*) towards the groove of attachment of the membrane (*sulcus tympanicus*) like the spokes of a wheel. The circular fibres are chiefly arranged near the circumference of the membrane. The handle of the malleus is firmly fixed throughout its whole length to the fibrous layer of the membrane.

The length of the various walls of the external auditory meatus has been noticed. There is of course a corresponding obliquity of the tympanic membrane, both in the vertical and lateral directions. The roof of the canal (which is much shorter than the floor) meets the plane of the tympanic membrane at an angle of 140°, whilst the floor forms an acute angle of 27° with the membrane (*Stereogram III*). The anterior wall being longer than the posterior, there is also a slope from behind forwards in the plane of the membrane (*Stereogram XVII*). This, as we shall see, has to be counted upon when attempting to remove foreign bodies from the ear by syringe or by instruments.

II.—THE MASTOID PROCESS.

A working knowledge of the **Anatomy of the Temporal Bone** is not easily obtained, but is quite necessary for the operative treatment of disease within it. The external surface of the bone, as seen on the side of the skull, shows only two of its great divisions: the mastoid process behind, and the squamous portion above and

in front. The external auditory meatus is placed between them, in front of the mastoid process and below the squamous portion. The petrous portion, which also helps to form the external auditory canal, springs wedge-shaped from the junction of the mastoid and squamous portions, and passing inwards and forwards, forms part of the base of the skull (*Stercogram IV*).

The most important land-marks on the external surface of the bone are these. The tip of the mastoid process, rough, prominent, and easily felt through the soft tissues; the posterior root of the zygoma and its prolongation backwards and upwards; the supra-mastoid crest, also felt through the soft parts; and a small spine or point of bone, the supra-meatal spine, or *spine of Henle,* lying at the upper and posterior angle of the external auditory canal. This spine is only discovered after the soft parts have been reflected, but is of great value as a guide to the deeper structures, especially the mastoid antrum. The spine is not quite constant, but a little *fossa* above and behind it, usually perforated with small foramina, is constant. The supra-mastoid crest, or *linea temporalis*, corresponds with the floor of the middle fossa of the skull, and marks the upper limit of bony excavation during the mastoid operation (*Stereograms IV, VII*).

If a saw-cut be made through the **Mastoid Process** parallel with its surface, or with the side of the skull, the mastoid cells will be displayed. These vary from mere pin-hole cavities disseminated through the bone, to a few large cavities occupying the whole process; and three divisions are recognized on this basis:—

1. *Diploetic* mastoid processes, with cells about the size of a pea, and occupying most of the substance of the bone (*Stereogram VII*).

2. *Pneumatic* mastoid processes, with a few large cells occupying almost the whole of the bone (*Stereogram VIII*).

3. *Eburnated* mastoid processes, with hardly any trace of cells. This last is commonly but not always a diseased condition (*Stereogram IX*).

Whatever the distribution of the cells in the mass of the process,

one is always present—the antrum (*Stereograms V, XV*) though it may be small. The **Mastoid Antrum** is placed beneath the upper and anterior part of the mastoid process, about half-an-inch on an average below the supra-meatal spine, and just behind the tympanic attic or upper part of the drum cavity (*Stereogram V*). All the other cells converge towards this cell, which (except perhaps in pneumatic mastoids) is the largest cell of all. The floor of the antrum corresponds to about the middle of the posterior wall of the external auditory canal (*Stereograms XVII, XXIV*).

Its communication with the tympanic cavity renders the mastoid antrum of great surgical importance. It is generally short and wide. Like almost every other feature of this bone, however, the width of this communication varies. It may be narrow and easily occluded. It is this factor of variability which makes the surgery of the temporal bone at once so difficult and so fascinating. Were the antrum always at the same depth, always of the same size, always freely communicating with the tympanic cavity, mastoid surgery would be simpler but less interesting. Perhaps the most constant feature of the mastoid antrum is its proximity to the middle fossa of the skull. A mere shell of bone separates the antrum from the brain, in thickness averaging hardly 1 mm. (*Stereogram XV*). The mastoid antrum may be displayed in a dry specimen by a vertical transverse section just behind the external auditory canal.

III.—THE MIDDLE EAR.

The anatomy of the middle ear or tympanum is of great importance. Emptied of its contents, or with at least the tympanic membrane removed, and viewed through the external auditory canal, its contour seems almost circular, corresponding with the tympanic membrane (*Stereogram XXII*). But if the same specimen be cut from above downwards, in the axis of the external auditory canal, its real contour will be seen (*Stereogram XIX*). Above the part seen through the canal—middle tympanum or *atrium*—is another about half as large as this, the *attic* or epitympanic recess (*Stereogra*[illegible]*II, XIX*.

XXIII). This lodges the bulk of the ossicles—the ***malleus*** and ***incus***—only the long processes of which stretch into the tympanum proper to be seen through the drum membrane. Here suppurative disease is particularly obstinate and dangerous, for caries of the ossicles often goes along with it, and the middle fossa of the skull is just through the roof of the attic or ***tegmen tympani*** (*Stereograms XIX, XIV*). A much smaller cavity or pocket below the atrium or tympanum proper, and occupying the floor of the middle ear, is sometimes called the ***hypotympanic cavity*** or cellar of the tympanum proper (*Stereograms XVII, XIX*). The floor of the external auditory canal rises just outside the attachment of the membrane into the sulcus tympanicus, and thus increases the depth of the floor of the middle ear and the size of the cellar, which often gives great trouble in treating suppurative disease of the middle ear (*Stereograms III, X, XI*).

The Tympanum is an irregularly-shaped cavity, wider above than below, and with a recognizable roof and floor, also inner, outer, front and back walls. The roof, or ***tegmen tympani***, separates the tympanic attic from the brain. Across it runs the remains of the petro-squamosal suture, open in the child, sometimes partially open in the adult, except for the fibrous tissue which closes it, and a common pus channel from the middle ear to the middle fossa of the skull. Lying under the tegmen tympani and occupying the attic, are the heads of the ***malleus*** and ***incus***, attached to the tegmen by ligamentous bands (*Stereograms XI, XLIII*).

The floor of the tympanum has been noticed as bounding the cellar or hypotympanum. Its level depends on the size of the *fossa jugularis*, which lies just under it, and sometimes there is an opening in the bone here communicating with the fossa below. Infection of the jugular vein is therefore possible from the middle ear, and careless manipulation may damage a jugular bulb placed further upwards and forwards than usual.

The posterior wall of the tympanum shows a large opening in its upper part which is partly occupied by the short process of the incus, and which, as the *aditus ad antrum*, communicates with

the mastoid antrum placed above and behind (*Stereograms XX, XXIV*). Below this, also on the posterior wall, is the ***eminentia pyramidalis***, or pyramid, containing a canal for the stapedius muscle (*Stereograms XIX, XXXVIII*).

The anterior wall of the tympanum shows the opening of the Eustachian tube, which leaves the drum cavity nearer its roof than its floor, and consequently is not in the best position for draining the middle ear into the throat. The floor of the tympanum slopes gradually upwards towards the opening of the Eustachian tube. During the later stages of the radical mastoid operation, the upper opening of the tube can easily be blocked by a well-made cotton tip pushed into it from the mastoid wound, and thus, during the operation of washing the wound clear of bone dust, etc., fluid is effectually prevented from reaching the throat during anæsthesia (*Stereograms I, XXIII*). Just above the bony Eustachian tube, running parallel with it, and separated from it by a bony ridge, is the canal for the *tensor tympani* muscle (*Stereograms XX, XXI, XXIV*).

The outer wall of the tympanic cavity is formed by the **Membrana Tympani** (*Stereogram XXIV*). The *inner wall* is the most complicated, and in many ways the most important of the boundaries of the tympanic cavity. It is irregular in surface. Running across it from before backwards is the broad *promontory* tapering towards the posterior part, and there separating the oval window above from the round window below (*Stereograms XIX, XX, XXI*). Above the oval window, which in the fresh state is occupied by the footplate of the *stapes*, and running downwards and backwards along the postero-superior border of the inner tympanic wall towards its exit by the stylo-mastoid foramen, is the *Fallopian canal* for the facial nerve. In suppurative middle-ear disease this nerve is often exposed by carious erosion, and during the radical mastoid operation it is apt to be wounded by chisel or burr, unless carefully guarded (*Stereograms XXVI, XXVII*). Below and behind the promontory, and placed obliquely, looking downwards and outwards, is the *fenestra rotunda* (occupied by the membrana tympani

secundaria) which leads to the cochlea from the tympanum. Behind that part of the Fallopian canal which runs above the oval window, is a prominence due to the presence underneath it of the external semicircular canal, which, like the facial nerve, may be damaged by disease or injured by operation (*Stereogram XXVI*). The canal for the tensor tympani muscle passes from the anterior tympanic wall across the internal tympanic wall, near its superior boundary, and ends above the oval window, where the tendon of the muscle passes over a hook-shaped process—the *processus cochleariformis*—to be inserted into the upper part of the handle of the malleus (*Stereogram XI*). In this latter part of its course the tendon of the tensor tympani has an outward course across the tympanic cavity towards the tympanic membrane.

The **Auditory Ossicles** are the malleus, the incus, and the stapes (*Stereogram XLII*). The *malleus* consists of a head, neck, handle, a short process, and a slender process, which last easily breaks away from the bone. Near the junction of the handle with the neck of the bone is the attachment for the tensor tympani muscle. The slender process passes forwards and is attached to the fissure of Glaser (*Stereogram XLII*). The posterior surface of the head has a cartilage-covered surface for articulation with the incus. The handle is fixed to the fibrous layer of the tympanic membrane.

The *incus* has a body, a short and a long process. The body articulates with the malleus in front, the short process passes backwards, and is attached to the posterior tympanic wall by a definite ligament. The long process passes downwards, almost parallel with the handle of the malleus, but is shorter, and is placed further back and more deeply within the drum cavity. Still it can often be seen through the membrane, especially if the latter be in-drawn or retracted. The tip of the long process (sometimes called the *os orbiculare*) is knob-shaped and slightly turned inwards, and on the inner aspect of this part of the long process is an articular surface for union with the head of the stapes. The general form of the incus is that of a bicuspid tooth, the

two roots of which diverge a good deal (*Stereogram XLII*, also *Fig*. 1, p. 22).

The *stapes* is exactly like a stirrup. It consists of a head, neck, two crura, and a base or foot-plate. The foot-plate is fixed loosely within the oval window by fibrous tissue, which passes to the sides of the latter. The neck gives attachment to the tendon of the stapedius muscle, which reaches the stapes from the posterior tympanic wall. The head articulates with the tip of the long process of the incus. The stapes passes inwards towards the oval window almost at right angles to the direction of the long process of the incus (*Stereogram XLII*).

The malleus and incus are connected by ligamentous bands to the roof of the attic, and to the anterior and posterior walls of the tympanic cavity. These bands not only to some extent control the movements of the ossicles, but break the upper part of the tympanic cavity into separate pockets or spaces, which do not communicate freely with the bulk of the tympanic cavity placed below them. Consequently, suppurative processes going on in the upper part of the tympanum are difficult to treat, and are apt to become chronic. (See Shrapnell's membrane and Prussak's space, *Fig*. 1, p. 22; and *Stereogram XXXVIII*.)

Surgically the most important of these ossicular ligaments are: (1) The anterior ligament of the malleus, a strong fibrous band extending from the front of the head of the malleus to the fissure of Glaser. It surrounds the processus gracilis. (2) The external ligament of the malleus, extending from the neck of the malleus to the margin of the notch of Rivini in the tympanic ring. These are the chief fibrous bands which must be severed before the malleus is dragged downwards and outwards in the operation of ossiculectomy. (3) The superior ligament of the malleus, extending from the head of the malleus to the tegmen tympani. This ligament is slender. (4) The internal ligament of the malleus, surrounding the tensor tympani, and extending inwards along with that muscle, from the root of the handle of the malleus across the tympanic cavity to the processus

cochleariformis in the internal tympanic wall. This ligament and the muscle are divided in tenotomy of the tensor tympani. They do not usually require separate division in ossiculectomy. (5) The ligament of the incus extends backwards as a short strong band, and connects the short process of the incus with the posterior tympanic wall at the margin of the aditus ad antrum. After the malleus has been removed, it is the only important attachment of the incus.

Most of the contents of the tympanic cavity have now been noticed. In addition to the tympanic ossicles, and the stapedius and tensor tympani muscles, the cavity contains the *chorda tympani nerve*. This nerve passes forward across the drum cavity in front of the long process of the incus, and behind the handle of the malleus (*Stereograms XXIII, XXIV*; also *Fig*. 1, p. 22).

The *mucous membrane* of the tympanum is similar in structure and function to mucous membrane elsewhere, such as the nose. Its connective tissue layer performs the function of a periosteum to the ossicles, which are dependent on it for their nourishment. The mucous membrane readily swells, and almost fills the cavity in inflammatory conditions. It extends by the aditus to the mastoid antrum and cells, and in the aditus this swelling may be a factor in preventing exit of discharge from the antrum to the drum cavity. It is continuous anteriorly with the mucous lining of the Eustachian tube.

The Eustachian Tube is an inch and a-half long, and stretches from the middle ear inwards, forwards, and downwards to the naso-pharynx. The slope during this course of an inch and a-half is great, for the pharyngeal opening is an inch below the level of the tympanic opening (*Stereogram I*).

The Eustachian tube is composed of a bony and of a cartilaginous portion. The upper and outer or bony (tympanic) portion extends for half an inch from the tympanic cavity, which latter it leaves at the upper and anterior part, so that the tube

does not form an efficient drain for a fluid-filled middle ear (*Stereogram XXIII*). The inner and lower two-thirds of the Eustachian tube are composed of an incomplete trumpet-shaped plate of cartilage, the sides of which are so completed by fibrous tissue, that a tube of an inch long is formed (*Stereogram I*). Between the two parts of the tube—the bony and cartilaginous—the lumen is very narrow, only one-twelfth of an inch, compared with one-sixth of an inch at the tympanic and one-fifth at the pharyngeal end. The narrowest part, at the junction of the bony and cartilaginous portions, is called the isthmus (*Stereogram I*). The cartilaginous plate increases in width from the isthmus inwards towards the pharynx, so that on arrival at the latter, the plate not only forms the median boundary of the tube, but is folded well over the upper boundary towards the outer wall, and slightly over the lower boundary. Thus, at the pharyngealcopening only part of the outer wall is left to be completed by membrane. The upper wall of the tube is fixed to the base of the skull by fibrous tissue. The opening of the tube on the pharyngeal wall is at the level of the posterior extremity of the inferior turbinated bone, and nearly half an inch behind it.

The Eustachian tube is normally closed, but is under the control of three muscles which act as dilators. These are (1) The *levator veli palati*, under the control of the seventh nerve; (2) The *tensor veli palati*, under the control of the third division of the fifth nerve; (3) The *palato-pharyngeal* muscle, under the control of the pneumogastric nerve.

The Eustachian tube is lined by mucous membrane, which is thrown into folds along the walls of the cartilaginous portion, but is very thin and more closely applied to the walls of the bony portion. The epithelium covering this mucous membrane is cylindrical, and becomes ciliated in the cartilaginous portion.

Physiology of the Eustachian Tube.—That the Eustachian tube communicates with the middle ear, is discovered by every one who has forcibly to blow the nose during the course of a cold in the head. If one swallows with the nose closed, some of the

air in the mouth and pharynx is swallowed, and the partial vacuum extends up the tubes to the middle ear. If now swallowing take place with the nostrils open, the air again enters the tube from the pharynx, and the sensations attending the rarefaction of the air in the middle ear disappear. Normally, its walls are closely apposed, but the muscular contractions occurring during swallowing open the tube, and any change in air pressure occurring within the pharynx (condensation or rarefaction) extends also to the middle ear. Apart from swallowing, if the air pressure in the naso-pharynx be sufficiently raised, the resistance in the closed tube is overcome, and air enters the middle ear. This takes place in Valsalva's experiment, or method of inflation of the middle ear, when with the mouth and nose closed, a forcible expiratory effort is made.

In any case, therefore, where the air pressure in the middle ear has become altered, we have in the Eustachian tube a channel through which the fact of such alteration can be ascertained, and in many cases the faults due to such alterations of pressure can be rectified.

When looking through the speculum at the tympanic membrane, or when operating within the middle ear or in the mastoid process near the middle ear, it is well to have a clear idea of what structures lie internal to and around the membrane. If the line of the handle of the malleus be continued downwards and backwards (*Fig.* 1) till it cross the lower border of the membrane, the latter will be divided into two nearly equal parts, the anterior part being, however slightly, the smaller, the posterior the larger. If now an imaginary line be thrown across this at right angles, and be made to cross the first line at the umbo or tip of the handle of the malleus, the membrane will be divided into quadrants, A, B, C, D, the *postero-superior* of which is the largest. This quadrant (A) of the membrane corresponds to or contains the long process of the incus, the stapes, the foramen ovale, the stapedius muscle and its insertion into the pyramid, the facial nerve within the Fallopian canal, and the chorda tympani nerve. The *postero-inferior*

quadrant (B) contains the foramen rotundum, part of the tympanic cellar, and sometimes a part of the jugular bulb. Turning now to the anterior division of the drum-head, the upper or *antero-superior* (C) contains or corresponds to the tympanic opening of the Eustachian tube and the groove or semi-tube for the tensor tympani muscle. The *antero-inferior quadrant* (D) contains the

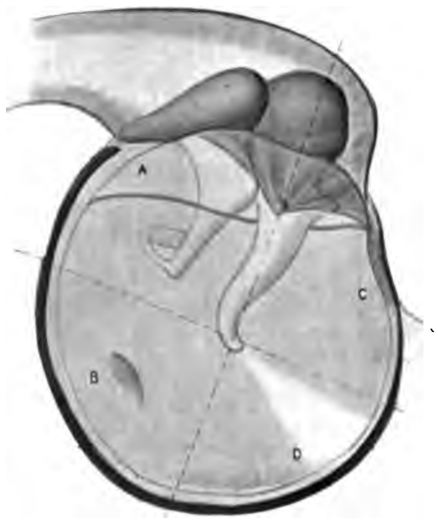


Fig. 1.—Scheme of the Tympanic Relationships.

cone of light; the internal tympanic wall here is marked by no structure of importance, but below and in front of it is the carotid canal.

The heads of the malleus and incus lie chiefly outside the membrane above the postero-superior quadrant; the short process of the malleus with the membrana flaccida above it corresponds to the upper pole of the division between the anterior and posterior parts of the membrane. The promontory lies internal to and slightly above the umbo, and in cases of retraction of ·m-brane, the umbo is often swung upwards so as to e

promontory. Similar contact with and adhesion of the umbo to the promontory occurs in cases of chronic middle-ear suppuration.

There are three structures, the whole relations of which must be clearly before the mind of the operator who would deal safely and successfully with suppurative disease in the temporal bone —the **Facial Nerve,** the **Sigmoid Sinus,** and the **Floor of the Middle Fossa of the Skull.**

All have been referred to; but at the risk of reiteration their relations to the cavities in the temporal bone must be traced throughout their entire course. The need for this is easily understood. Take the sigmoid sinus for instance. Compare the case of the surgeon who *accidentally* opens this blood-vessel before he has cleared its environment of pus, granulations, and pathogenic germs; and the case of the surgeon who, with a clear idea of all the relations of the vessel, only opens it *deliberately* after having made its surroundings clean. The one is the position of control, strength, and safety; the other of hurry, weakness, and danger. Almost all recent advances in aural surgery have been based on an accurate knowledge of the relationships of these three structures; and all competent operators, instead of being now afraid to approach them, are able to avoid them with certainty, or deliberately to expose them, without adding to the risk of the patient.

Returning therefore to the **Facial Nerve,** it may be said that intentional exposure of the facial nerve is seldom the object of the surgeon. It is often exposed for him by the disease, for the cure of which he is asked to operate. This usually takes place within the middle ear, through which its course has just been traced. Extensive necrosis of the mastoid process sometimes destroys it in its vertical course towards the stylo-mastoid foramen. This condition is commonest in young, unhealthy children, the subjects of tuberculous middle-ear disease; but every radical mastoid operation brings the instruments of the operator very close to its canal. The nerve leaves the cavity of the skull along with the auditory nerve, by the internal auditory meatus. At the bottom

of the meatus it enters the Fallopian canal, and follows the course of this canal to the stylo-mastoid foramen. At first the course is nearly horizontally outwards above the cochlea, and in front of, and below the semicircular canals. Then it takes a sharp bend on itself, forming an acute angle in its course. At this angle it forms the *geniculate ganglion*, and gives off the *great superficial petrosal nerve*. The course of the nerve is then horizontally backwards, across the inner tympanic wall, above the oval window. At the pyramid (origin of the stapedius) it bends sharply downwards, and runs almost perpendicularly to the stylo-mastoid foramen. Just before it assumes the vertical direction, it runs close to the floor and inner wall of the aditus ad antrum, and this must be avoided by the chisel or burr in operating. Just after it makes the turn to assume the vertical in the mastoid process, the facial gives off the *chorda tympani nerve*, which passes forwards between the descending processes of the incus and malleus to the fissure of Glaser, across the cavity of the tympanum, close to the membrana tympani (*Stereograms XXIV, XXXVIII*).

The second of these three structures is the **Lateral Sinus.** The course of this vessel is marked by the groove on the inside of the skull, extending from the internal occipital protuberance to the foramen jugulare, below which it is continued as the internal jugular vein in the neck. The groove is best marked in its course downwards, inwards and forwards, on the inner aspect of the mastoid process, where it is known as the *sigmoid groove*, and abuts against the posterior set of mastoid cells (*Stereogram XIII*). At the lower end of the sinus, just as it leaves the skull, the vessel takes a sharp, short turn upwards and forwards, to form the *jugular bulb*, and this is sometimes in close proximity to the posterior and lower part of the tympanic cavity.

The usual distance of the sigmoid sinus from the spine of Henle is 10 mm., but sometimes the sinus is found so far forward as to lie almost immediately behind the posterior wall of the external auditory canal, and just below the surface of the mast process. The mastoid emissary vein perforates the skull at

an inch behind the tip of the mastoid process (*Stereogram XXVI*), and communicates with the sigmoid sinus. The sigmoid groove, its contained sinus, and the jugular bulb, are thicker and carry more blood on the right side than on the left, for the communication with the heart is more direct by the right innominate vein than by the venous trunks of the left side. Within the skull the sigmoid sinus receives the superior petrosal sinus, and the jugular bulb the inferior petrosal sinus. These vessels run along respectively the superior and inferior borders of the posterior surface of the petrous portion of the temporal bone (*Stereogram XIII*). Behind the sigmoid sinus and below the transverse sinus, the cerebellum may be safely reached in exploring for abscess. This may be done by making a separate trephine opening, but in ear disease a mastoid wound usually exists already, and the cerebellar fossa is best reached by extending this wound in the bone backwards across the sigmoid sinus.

The last of the triad of important relationships is that of the middle ear and mastoid antrum to the **Middle Fossa** of the skull. This corresponds with the supra-mastoid crest, but the posterior part of the ridge curves upwards more rapidly than does the floor of middle fossa, and a chisel-cut carried directly inwards, along the whole line of the crest, would in many cases expose the dura mater and, in some, perforate it. But if the chisel-cut be made to slope *downwards* and inwards instead of *directly* inwards, the antrum can be reached from the line of the supra-mastoid crest, without exposing the dura mater. If the middle fossa of the skull contains pus, this may be reached by a trephine opening in the squamous portion of the temporal bone, or by extending upwards an already existing mastoid wound, and thus reaching the middle fossa through the tegmen tympani.

Blood-Vessels and Nerves of the Middle Ear.—The *arteries* of the tympanum are the tympanic branch of the internal maxillary, the ascending pharyngeal, a branch of which passes up the Eustachian tube, the petrosal branch of the middle meningeal artery, and branches of the internal carotid, which latter pass

through small openings—the canaliculæ carotico-tympanici—in the walls of the carotid canal. The stylo-mastoid artery supplies the facial nerve, and also sends branches to the tympanum.

The *veins* of the middle ear pass into the temporo-maxillary vein, the superior petrosal sinus, the lateral sinus, the internal jugular, and the pharyngeal veins. The veins pass directly into the sinuses, have no valves, and afford direct communication for pathogenic organisms to the intra-cranial and other surrounding structures.

The chorda tympani and the facial nerves in their relationships to the middle ear have already been noticed. The tympanic plexus is formed by the tympanic branch of the glosso-pharyngeal nerve, a branch of the great superficial petrosal nerve, a branch of the small superficial petrosal nerve, and the small deep petrosal nerve (a branch of the sympathetic). These form the tympanic plexus on the anterior part of the inner tympanic wall.

Channels of Infection in Suppurative Ear Disease. — In carrying infection from the middle ear and the mastoid process to the surrounding structures, the following pus channels may be engaged :—

1. The *Petro-squamosal suture*, from the middle ear to the middle fossa of the skull.

2. The *Squamo-mastoid suture*—to the surface of the mastoid process.

3. *Gap in the tympanic ring*, usually open till the fifth year, from the external auditory canal to the articulation of the jaw.

4. *Fenestræ* between the posterior mastoid cells and the sigmoid sinus, to the cerebellar fossa and sigmoid sinus.

5. *Fenestræ* in the tegmen tympani and the tegmen antri, to the middle fossa of the skull.

6. The *perforations for blood-vessels* in the fossa above and behind the supra-meatal spine and supra-spinous (mastoid) fossa, to the surface of the mastoid process from the mastoid cells.

7. The fenestræ (*round and oval windows*) in the internal wall of the tympanum, to the labyrinth.

8. The *internal auditory meatus.*
9. The *aqueductus vestibuli* and *aqueductus cochleæ.*
10. *Hiatus Fallopii* and to the middle fossa of the skull.

The Ear in Children.—(*Stereograms XXXII* to *XXXVI.*)—The ear in children presents certain important differences from that in the adult. The external auditory canal is much narrower, but the middle ear is relatively larger than in the adult. It is said that the ossicles and tympanic membrane are absolutely as large as in the adult. At birth the membrane is almost horizontal, and forms a continuation of the roof of the external auditory canal. The Eustachian tube is wider and shorter, and more easily inflated. There is no bony external auditory canal at birth. During the earliest years this canal is developed from the tympanic ring (*Stereogram XXXII*) and by the growth backwards and outwards of the mastoid process. With the exception of the antrum, which is well represented at birth, there are no cells in the mastoid process of the new-born. These appear with the back wards and downwards development of the mastoid process, which at birth is very small. The squamo-mastoid suture (*Stereograms XXXIII, XXXIV*) and the petro-squamous sutures are open at birth.

IV.—THE INTERNAL EAR.

The anatomy of the internal ear must be studied with regard to two classes of cases: (1) Those in which deafness, giddiness, etc., call for the accurate localization of the causes of these symptoms; (2) Those in which suppurative processes in the middle ear and its adnexæ call for operative treatment for their removal. The knowledge required for the management of the second class of cases is chiefly that of the macroscopic anatomy; but this knowledge must be very accurate, for in the case of the trio of important structures which has just been discussed—the facial nerve, the lateral sinus, and the brain—the instruments of the surgeon must approach the delicate structures of the internal ear with precision

and without the risk of injuring them. For the diagnosis and management of the first class, the knowledge of the macroscopic anatomy must be supplemented by that of the minute anatomy.

The two fenestræ of the inner tympanic wall represent the only gaps in the outer side of the bony capsule which encloses the internal ear (*Stereograms XIX, XX*). The foot-plate of the stapes closes the fenestra ovalis, and just beyond the foot-plate from the tympanum is the *vestibule*, the central division of the internal ear. The *cochlea* is in front of this, and the semicircular canals behind (*Stereogram XXXI*), and all are enclosed in the petrous portion of the temporal bone. The first turn of the cochlea, beginning in the vestibule, runs forwards and downwards, and its convexity causes the eminence called the *promontory* on the inner tympanic wall (*Stereograms XIX, XX, XXI*). The axis of the cochlea—the *modiolus*—points forwards and upwards towards the knee of the carotid artery (*Stereograms XXX, XXXI*). The external semicircular canal lies above the bend of the facial nerve, and above and behind the foramen ovale, and therefore quite near the internal tympanic wall, so that it may, like the facial nerve and the cochlea, be injured by burr or drill in manipulations within the middle ear (*Stereogram XXVI*). The only other point where the internal ear comes quite near the surface of the petrous bone, is on its upper aspect within the skull, where the upper part of the superior semicircular canal forms the *eminentia arcuata* (*Stereogram XLIII*).

Taking the three parts of the internal ear separately, the **Vestibule** is seen to be divided into two by a crest or ridge, the *crista vestibuli*; the pit or depression below and anteriorly is called the *fovea hemispherica*; that above and behind, the *fovea hemi-elliptica*. These foveæ lodge respectively the *saccule* and the *utricle*, the utricle being behind and the saccule in front.

In metal corrosion preparations of the inner ear, the aqueductus vestibuli may sometimes be seen as a slender process leading from the vestibule to the posterior surface of the petrous bone, within the skull, behind the internal auditory meatus, and between the superior petrosal sinus and the sigmoid sinus. The aqueductus

contains a process of the membranous vestibule which communicates with the sub-dural space.

Posteriorly and superiorly the vestibule receives the openings of the **Semicircular Canals,** five in number, not six, for the posterior and superior canals unite above and behind, and enter the vestibule as a common tube (*Stereograms XXVIII* to *XXXI*). The semicircular canals lie behind the vestibule. They are three in number, and each is about 1 mm. in diameter (width of the bony canals). They are named the superior, the posterior, and the external canals. The surgical anatomy of these canals has been already noticed. The superior is vertical, but is at right angles to the side of the head; the posterior is also vertical, but is parallel with the side of the head; the external is horizontal, and at right angles to the side of the head. Each canal is almost at right angles to the other two. Each really makes much more than half a circle outside the vestibule, nearly two-thirds, the circle being completed within the vestibule. Each has a dilated part near one end, the *ampulla* (*Stereograms XXVIII* to *XXXI*).

The membranous semicircular canals correspond in a general way with the bony canals, but are of course smaller. They each present—like the osseous canals which contain them—a dilated part or ampulla, in which are found terminal branches of the auditory nerve. Between the membranous and bony canals is the *perilymph*: within the membranous canals the *endolymph.*

The Cochlea lies in front and below the vestibule (*Stereograms XXX, XXXVIII*). It consists of two and a-half turns arranged upon one another, so that a shell-like structure of pyramidal shape is produced, the base of the pyramid being turned inwards and backwards towards the internal auditory meatus, and the apex outwards and forwards, towards the knee of the carotid artery. The centre pin or bony axis round which these turns are wound is about a quarter of an inch long—height of the cochlea. It is called the *modiolus*. In the following description of the cochlea the term "inwards" denotes direction towards the centre pin, and the term "outwards" direction towards that wall of the cochlea furthest

removed from the centre pin). This coiled tube is divided into two *scalæ* or staircases by a spiral lamina, which projects from the centre pin right round the two and a-half coils. In the lower coil this lamina stretches more than half way across the lumen of the tube, but as the upper coil is reached, the bony lamina spiralis is relatively much less prominent (*Stereogram XXXIX*). All through the cochlea, however, the partition is continued across to the outer wall by the *basilar membrane* (*Plate I*), a fibrous structure fixed by its inner edge to the bony lamina spiralis, and by its outer to the inner aspect of the outer wall of the tube. Upon this basilar membrane are erected the *arches of Corti*, and here are distributed the endings of the cochlear nerve. As the bony lamina spiralis is relatively most developed in the lower turn, and least in the upper, the membranous continuation of it towards the outer wall is relatively least developed below, and most above. The upper scala communicates below with the vestibule, and is called the *scala vestibuli*; the lower communicates with the tympanum by the round window, and is called the *scala tympani*. The scalæ communicate at the apex of the cochlea by a small aperture, the *helicotrema*. Near the lower part of the scala tympani a small canal, the *aqueductus cochleæ*, leaves the cochlea, and passing nearly half an inch downwards and inwards through the substance of the petrous bone, it emerges on the inner aspect of the jugular fossa.

Such are the chief naked-eye appearances which are discovered on an examination of the bony labyrinth, as it lies in the substance of the petrous bone. The bony labyrinth is filled with fluid—the perilymph. In this floats the membranous labyrinth, supported by its attachments to the bony labyrinth and containing the endolymph.

The *auditory nerve* enters along with the facial by the internal auditory meatus (*Stereograms XXXVII, XXXVIII*), and is distributed to the labyrinth in six divisions: one to the organ of Corti in the cochlea, one to the utricle, another to the saccule, and three to the ampullæ of the semicircular canals. In the utricle, the saccule, and the three ampullæ, the nerve-endings have a great deal in common. They run to thickened patches on the inside of the labyrinthine

wall, and are distributed to specialized epithelial structures ornamented by auditory hairs. These patches are called the *cristæ acusticæ* in the ampullæ, and the *maculæ acusticæ* in the utricle and saccule of the vestibule. Both in the utricle and saccule and in the ampullæ of the semicircular canals, crystals of carbonate of lime called *otoliths* occur. These are most abundant at the cristæ and maculæ. The bony labyrinth has only five openings outwards from itself—the two fenestræ into the middle ear, the aqueducts of the vestibule and the cochlea, and the internal auditory meatus. These are all possible pus avenues, and must be borne in mind by the surgeon.

For the diagnosis and management of deafness, the minute anatomy of the cochlea must be further stated. Here almost certainly the essential organ of hearing is placed. We have seen that the lumen of the tube of the cochlea is divided into two scalæ by the lamina spiralis, and its extension outwards—the basilar membrane; but a third tube is shut off between these two, the duct or *canal of the cochlea.* This tube is blind at both ends. It extends from the apex of the cochlea, the helicotrema, to the base at the commencement of the lamina spiralis in the vestibule, and it communicates with the saccule by means of a very fine flask-shaped prolongation, the canalis reuniens. The duct of the cochlea is formed thus. Stretching from near the insertion of the basilar membrane to the lamina spiralis, and extending in an upward and outward direction to be attached to the wall of the bony cochlea, is a very fine, almost homogeneous membrane, the membrane of Reissner. Thus a triangular tube is shut off from the scala vestibule, having for its floor the basilar membrane, its outer wall the bony cochlea, and its roof the membrane of Reissner. This is the canal or duct of the cochlea, and the structures within it contain the essential part of the organ of hearing. These are spread out on the floor of the tube, the basilar membrane, and are called the organ of Corti.

The **Organ of Corti** is composed of two sets of stiff rods, the inner and the outer rods, so placed that the heads of two or three

one is always present—the antrum (*Stereograms V, XV*) though it may be small. The **Mastoid Antrum** is placed beneath the upper and anterior part of the mastoid process, about half-an-inch on an average below the supra-meatal spine, and just behind the tympanic attic or upper part of the drum cavity (*Stereogram V*). All the other cells converge towards this cell, which (except perhaps in pneumatic mastoids) is the largest cell of all. The floor of the antrum corresponds to about the middle of the posterior wall of the external auditory canal (*Stereograms XVII, XXIV*).

Its communication with the tympanic cavity renders the mastoid antrum of great surgical importance. It is generally short and wide. Like almost every other feature of this bone, however, the width of this communication varies. It may be narrow and easily occluded. It is this factor of variability which makes the surgery of the temporal bone at once so difficult and so fascinating. Were the antrum always at the same depth, always of the same size, always freely communicating with the tympanic cavity, mastoid surgery would be simpler but less interesting. Perhaps the most constant feature of the mastoid antrum is its proximity to the middle fossa of the skull. A mere shell of bone separates the antrum from the brain, in thickness averaging hardly 1 mm. (*Stereogram XV*). The mastoid antrum may be displayed in a dry specimen by a vertical transverse section just behind the external auditory canal.

III.—THE MIDDLE EAR.

The anatomy of the middle ear or tympanum is of great importance. Emptied of its contents, or with at least the tympanic membrane removed, and viewed through the external auditory canal, its contour seems almost circular, corresponding with the tympanic membrane (*Stereogram XXII*). But if the same specimen be cut from above downwards, in the axis of the external auditory canal, its real contour will be seen (*Stereogram XIX*). Above the part seen through the canal—middle tympanum or *atrium*—is another about half as large as this, the *attic* or epitympanic recess (*Stereograms XVIII, XIX,*

XXIII). This lodges the bulk of the ossicles—the *malleus* and *incus*—only the long processes of which stretch into the tympanum proper to be seen through the drum membrane. Here suppurative disease is particularly obstinate and dangerous, for caries of the ossicles often goes along with it, and the middle fossa of the skull is just through the roof of the attic or *tegmen tympani* (*Stereograms XIX, XIV*). A much smaller cavity or pocket below the atrium or tympanum proper, and occupying the floor of the middle ear, is sometimes called the *hypotympanic cavity* or cellar of the tympanum proper (*Stereograms XVII, XIX*). The floor of the external auditory canal rises just outside the attachment of the membrane into the sulcus tympanicus, and thus increases the depth of the floor of the middle ear and the size of the cellar, which often gives great trouble in treating suppurative disease of the middle ear (*Stereograms III, X, XI*).

The Tympanum is an irregularly-shaped cavity, wider above than below, and with a recognizable roof and floor, also inner, outer, front and back walls. The roof, or *tegmen tympani*, separates the tympanic attic from the brain. Across it runs the remains of the petro-squamosal suture, open in the child, sometimes partially open in the adult, except for the fibrous tissue which closes it, and a common pus channel from the middle ear to the middle fossa of the skull. Lying under the tegmen tympani and occupying the attic, are the heads of the *malleus* and *incus*, attached to the tegmen by ligamentous bands (*Stereograms XI, XLIII*).

The floor of the tympanum has been noticed as bounding the cellar or hypotympanum. Its level depends on the size of the *fossa jugularis*, which lies just under it, and sometimes there is an opening in the bone here communicating with the fossa below. Infection of the jugular vein is therefore possible from the middle ear, and careless manipulation may damage a jugular bulb placed further upwards and forwards than usual.

The posterior wall of the tympanum shows a large opening in its upper part which is partly occupied by the short process of the incus, and which, as the *aditus ad antrum*, communicates with

inner rods fit into the head of an outer rod—the latter being less numerous than the former—whilst the feet of the inner rods are set widely apart from those of the outer, so that a triangle or arch is formed, of which the basilar membrane is the base, and the rods of Corti the sides. The juxtaposition of a great number of contiguous inner and outer rods thus placed, forms a tunnel within the ductus cochlea. Inside the line of inner rods is placed a set of epithelial cells, surmounted by stiff, bristle-like structures—the inner *hair-cells*; whilst outside the outer row of rods are placed several rows of such cells similarly surmounted by stiff bristle-like hairs. The tops of the hair cells and of the rods are worked into a net-like cuticular structure through which the hairs project, and the whole organ of Corti is overlaid by a coverlet or delicate film of fine reticular material, which springs from near the junction of Reissner's membrane with the upper surface of the lamina spiralis, and spreads outwards over the organ of Corti—the ***membrana tectoria***.

The cochlear branch of the auditory nerve passes up the canal in the centre of the modiolus, and gives off by foramina branches to the various turns of the cochlea as it ascends. At the entrance to the lamina spiralis, each branch or fibre has a ganglionic enlargement introduced into its course, and on emerging from the outer edge of the lamina spiralis, each fibre turns abruptly upwards and enters amongst the epithelial structures forming the organ of Corti (*Plate I*). The further course of the individual nerve fibres within the organ of Corti is not clearly understood, and the more minute study of the subject is not within the province of this work, but enough has been said to show that the organ of Corti is to be regarded as composed of sections, each section viewed from within outwards having the following elements: inner hair-cells, inner rods, outer rods, outer hair-cells; the whole being supported on corresponding stretched segments of the basilar membrane; and that the ultimate divisions of the auditory nerve are distributed to these segments.

It is interesting to note that the number of these segments

Fig. A.—Photo-micrograph of Section of first turn of Cochlea of a 5-months' human Fœtus. × about 60.

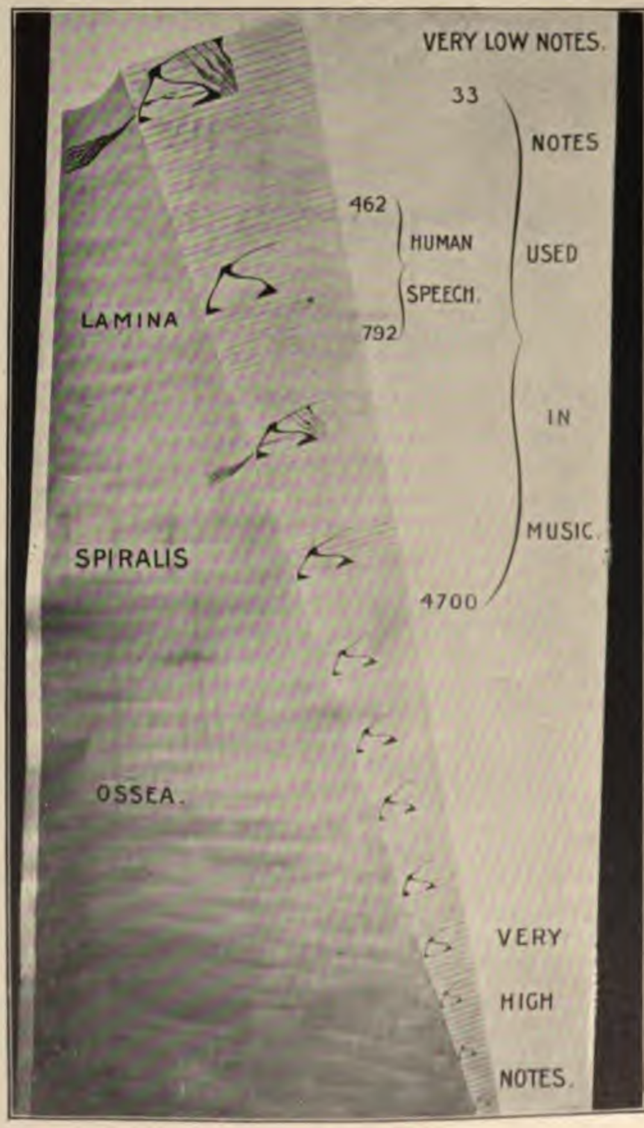
R.M. Reissner's Membrane
O.C. Organ of Corti
S.V. Scala Vestibuli
D.C. Ductus Cochlea
B.M. Basilar Membrane
S.T. Scala Tympani
L.S.O. Connective tissue which when ossified becomes the Lamina Spiralis Ossea
M. Connective tissue which becomes the Modiolus

Fig. B.—Same specimen as above, showing Ductus Cochlea, with Organ of Corti. × about 350.

R.M., O.C. and **B.M.** as in *Fig. A.*
E.C.T Embryonic connective tissue, which will become the periosteum of outer wall of Ductus Cochlea
M.T. Membrana Tectoria
C. Columnar epithelium on Basilar Membrane
C.T. Connective tissue of future Lamina Spiralis Ossea

(These photographs are from a section given the author by J. H. TEACHER.)

PLATE II.



Scheme of Cochlea.

as represented by the number of outer rods of Corti, bears some similarity to the number of recognizable musical intervals. Waldeyer has estimated that there are about 4,500 outer arch fibres in the human cochlea. This, as we shall see when studying appreciation for differences of pitch, is about what is required for a good musical ear.

For the sake of simplicity let it be assumed that the cochlea has been unwound from its centre pin, the modiolus, spread out as a ribbon (*Plate II*); the figure will then show diagrammatically the three sections: the osseous lamina spiralis, the basilar membrane supporting the organ of Corti, and the basilar membrane outside the organ of Corti.

SOUND IN ITS RELATION TO HEARING.

Sound is the effect produced upon the organ of hearing when a vibrating body disturbs the air or other conducting medium placed between itself and the ear. When the vibrations are irregular or non-periodic, the sound is called a noise. As the ear is in a real and structural sense a musical instrument, musical sounds must be studied at some length.

Musical Sounds are produced by the *periodic* vibrations of the sounding body. Such periodic movements give rise to corresponding periodic wave movements in the atmosphere—the usual conducting medium between the sounding body and the ear. Musical sounds differ with regard to their strength, their pitch, and their quality. The *strength* depends on the extent or amplitude of the vibrations; the *pitch* on the number of vibrations occurring in any unit of time; and the *quality* on the wave-form resulting from the vibrations in the sonorous body. It is with the characters of pitch and quality that we have to deal in studying musical intervals and their appreciation. The pitch of the sounds used in music ranges from thirty to forty vibrations per second to something under 5,000. The form of vibration associated with the simplest quality of musical sounds is called a pendular vibration. Its curve is the one which an ordinary pendulum would

describe, if its oscillation could be recorded as a curve on a moving surface. This curve is the ordinary curve of sines. The simple pendular vibration corresponds to the tones of tuning forks, which have no harmonics. All compound tones—tones with harmonics or upper partials—have more complicated wave forms, but all these latter can be broken up into as many simple waves as there are partials in the compound. These various simple waves co-exist in the air, just as several different systems of waves may co-exist on the same sheet of water. Before their meeting the components are alike in form; during their coalescence the value of each is represented by some modification in form of the resulting compound. After they have parted, the individual simple forms again reappear.

Most musical sounds, then, are not simple. That element which has the lowest vibration number, which is the loudest, and which therefore gives most of its character to the compound, is called the fundamental or prime. The other and higher elements, the upper partials, have vibration-numbers which are 2, 3, 4, 5, 6, or more times greater than the prime.

This theory of the nature of what we regard as separate musical sounds is not a new one. The presence of harmonics has been long recognized, but it is to Helmholtz that we owe the means of isolating and studying individual harmonics. By taking advantage of the phenomena of sympathetic resonance, he was able to emphasize the part of the compound corresponding to the proper tones of his resonators. These resonators pick out and strengthen their own tones from the other parts of a compound, just as the voice is seized by the string corresponding to it when a note is sung strongly into a piano.

Convinced, therefore, of the compound nature of the tones usually regarded as simple, let us see what relation the elements have to the prime. The first harmonic or second partial, as it is called, has twice the vibration number of the prime, and is the octave of the prime, the third partial has three times the vibration number and is the twelfth of the prime or fifth of the octave; the fourth partial has four times the vibration number of the prime

and forms the double octave; the fifth corresponds to the third above this double octave, and so on. These partial tones are in very simple relationship to the prime, and coincide with some of the chief intervals used in music.

Besides partials of higher pitch, another set of tones has to be taken into account in connection with musical intervals. These are the *differential tones* of low pitch, having vibration numbers

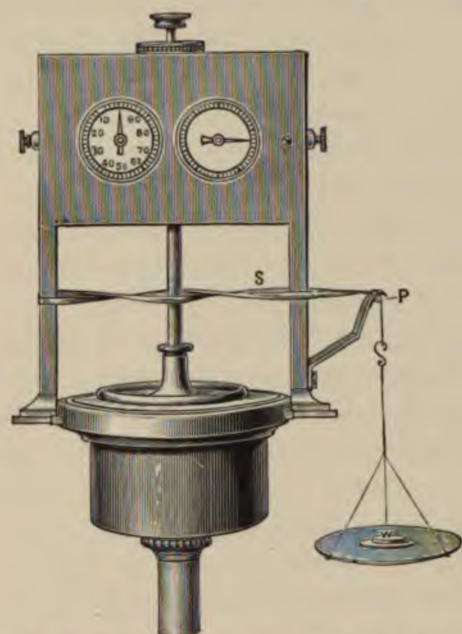


Fig. 2.—Siren, with addition for ensuring steadiness of Pitch. S. Strand of silk acting as a brake. P. Pulley. W. Weight varied with each note.

equal to the *difference* of the two primes or partials which combine to form them. They are of more practical importance than the other kind of combinational tones called summational. The loudest of these combinational tones are the differential tones of the primes, or of one prime and a powerful partial. They can be heard on any good harmonium.

The most convenient instrument for estimating the pitch of a musical sound is the *Siren*. This instrument (*Fig.* 2),

which consists of a circular brass chest with a series of holes in its lid, and of a revolving disc with a corresponding series of holes, can be made to emit a sound, the pitch of which will vary with the rate of revolution of the disc. Each coincidence of the holes in the disc and the lid of the chest, represents a puff of air or a sound-vibration, and the fusion of individual puffs or vibrations regularly emitted, gives a musical sound. The instrument is provided with a clock-work arrangement by which the revolutions of the disc are recorded, and these, multiplied by the number of holes in the disc, give the number of puffs or vibrations which go to make up the sound produced. This latter, when made to "beat" with any sound the vibration number of which it is necessary to discover, gives the means of ascertaining the pitch of the sound. The beats per second are added or subtracted according as the siren is flat or sharp, and the remainder is the vibration or pitch number of the sound in question.

A convenient and instructive method of treating musical sounds is to range them on a vertical scale, such as is used when measuring heat by the thermometer, the vibration numbers rising as we ascend the scale. Any two notes struck at random would probably give the idea of their having no sort of connection with each other, or the combination might have an actually disagreeable effect. In the latter case we call the phenomenon *dissonance*. But many pairs of the notes when struck together would give an idea of smoothness and harmoniousness which is peculiarly pleasant, and such we recognize as *consonance*.

This harmoniousness is greatest when the vibration ratio of the two notes struck is simplest. It is complete when the vibration numbers are the same. It is also perfect when they bear the simple ratio of 2 : 1, or when one is the octave of the other. When the ratio is 3 : 2 we have the perfect consonance of the fifth; when 4 : 3 that of the fourth; 5 : 3 the major sixth; 5 : 4 the major third; and so on; and we may say generally that the simpler the ratio the more perfect the consonance. And if we study this phenomenon of consonance

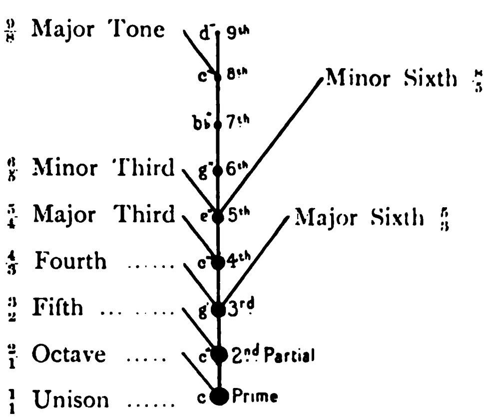
more closely, we shall see that the simple ratios just referred to tell us more. They explain the actual cause of the consonance. They tell us that the corresponding partial tones have the same vibration number. Thus, in the fifth, the third partial of the lower number and the second of the upper have the same vibration number, and are perfectly in unison. *Consonance*, then, is a smooth, uninterrupted, continuous flow of two tones.

Let us look at the nature of *dissonance*. When the notes sounded are nearly but not quite the same in vibration number, a disagreeable roughness is noticed. Suppose two pipes are sounded with 264 and 265 vibrations per second, one beat per second occurs. If the pipes be respectively 264 and 268, four beats per second are heard. The beats disturb the smoothness of the consonance. They are the essence of dissonance. Up to a certain point one can count them; then they become so rapid as not to be separately recognized, and one would hardly undertake to count them correctly, although they are quite distinguishable as rapid beats. When the interval is a semitone, the roughness is extreme, the dissonance is very marked, and the beats are so rapid that unless we had arrived at the dissonance by the preceding gradations we could hardly recognize it as due to beats.

As the distance between the beating tones is further increased the disturbance does not increase. At the major tone it is still great, but not so great as at the semitone, and as we approach the minor third it rapidly diminishes. The minor third, indeed, in the ascending scale is the first of those intervals where the vibration ratio is low, where the coincident upper partials are strong enough to have a marked effect, and consequently where the phenomenon of consonance again reappears. Ascending the scale further we come upon another dissonant area, the dissonance now being caused by the beating, not of the primes, but of the upper partials; then comes a point of agreement at the major third; then a dissonant area followed by the fourth; then another dissonant area followed by the fifth. With the exception of the octave, these last two intervals—the fourth and fifth—are the

best consonances we have. They are near the middle of the octave. The disturbance from the primes on the one hand, and the prime and first upper partial on the other, are least. Ascending the scale further, we have the consonances of the major and minor sixth comparable in respect of harmoniousness to the thirds, because separated by a distance from the first upper partial, similar to that between the third and the prime. On approaching the octave, the disturbance between the prime and the second partial of the lower note—its first upper partial—causes acute dissonance. On arriving at the octave we have the most perfect consonance.

Perfect consonance, therefore, means absence of all beats. It is the steady, uninterrupted flow of two tones which have no tendency to disturb or cut into each other. Theoretically it is impossible, unless we can be sure that the number of partials is limited; for the eighth and ninth partials in any compound are only a tone apart, the fifteenth and sixteenth only a semitone; and hence the braying, dissonant notes of some brass instruments which have the higher partials strongly developed. Practically it exists when neither the prime, nor any partial, nor any combinational tone is near enough any other element of the compound to form a beating pair with it. Dissonance is the rough, disturbed, broken sensation of tone caused by rapid beats, rapid enough to produce the disagreeable effect common to interruptions of sensation, but not so rapid as to leave the impression of a continuous flow of sound.



TREE OF CONSONANCE.

For the study of consonance the writer has constructed a tree of consonance or harmoniousness. The discs on the stem are meant to represent the relative strength of the various partial ch

qualities of tone as that of organ pipes. After the sixth or seventh their strength is hardly appreciable, and they may be almost disregarded. The intervals derived from the next lowest member in the scale are shown on the left side of the stem, and their position decides their degree of harmoniousness. The degrees of consonance of the unison, octave, fifth, fourth, and major and minor thirds are thus graphically shown. On the other side of the stem are ranged the other consonant intervals, the major and minor sixths, which must find their fellow-partials higher up in the tree than the position of the next higher partial. In a quality of tone such as is here supposed this necessarily weakens the consonance, for the partials lose force as we ascend the scale.

The tree is read as follows. In comparing, for example, the consonance of the fourth and major sixth, which spring from the same point on the stem, we call the fourth the better consonance because it finds its fellow-partial at the first higher step on the stem, whereas the sixth must travel to the second for its fellow. Again, when comparing the major third and major sixth, the latter must be called the more harmonious, for although it travels two steps to find its fellow, it starts with a stronger partial a step lower in the scale or stem.

The diagram, therefore, shows the intervals to be consonant or harmonious in the following order—the table referring only to intervals within the octave :—

Coincident Partials.		Relative Harmoniousness.	Name of Interval.	Distance from C.
1×1	=	1 or 100	1. Unison	C : C
1×2	=	$\frac{1}{2}$ or 50	2. Octave	C : C
2×3	=	$\frac{1}{6}$ or $16\frac{2}{3}$	3. Fifth	C : G
3×4	=	$\frac{1}{12}$ or $8\frac{1}{3}$	4. Fourth	C : F
3×5	=	$\frac{1}{15}$ or $6\frac{2}{3}$	5. Major Sixth	C : A
4×5	=	$\frac{1}{20}$ or 5	6. Major Third	C : E
5×6	=	$\frac{1}{30}$ or $3\frac{1}{3}$	7. Minor Third	C : E♭
5×8	=	$\frac{1}{40}$ or $2\frac{1}{2}$	8. Minor Sixth	C : A♭

PHYSIOLOGY OF HEARING.

Removal of the auricle does not seem to make much difference in the hearing power of people with normal ears, and it has been argued that the auricle has no essential use in human hearing. In people with nórmal hearing a certain amount of loss takes place without the loss being detected by any but accurate tests; but if the hollows of the auricle, and especially if the concha be filled up, and accurate tests applied, diminution in hearing power will be detected. Deaf and very old people instinctively discover the function of the auricle in hearing, and to increase its area and collecting power they place the hand behind it.

Probably the concha is functionally the most active part of the auricle. Its cup-shaped depression gathers the sound, the dispersion of which is prevented by the prominent tragus, and the wave is thus directed into the external auditory canal. The wave is next reflected to the concave posterior wall of the external auditory canal, just inside its orifice; and from this surface reflection takes place to the antero-inferior wall of the canal, whence they are once more reflected, to impinge on the surface of the tympanic membrane. When the air next the tympanic membrane becomes disturbed by the progressing sound-wave, the membrane is driven inwards, and as the malleus handle is firmly fixed into the membrane, this part of the malleus goes inwards with it. But the head of the malleus is not free to move inwards with the handle, its ligamentous attachments and its attachment to the incus interfering with this. The malleus becomes a lever, moving round an axis passing through its neck, its head carries the head of the incus with it, and as the heads of the bones move outwards together, the long process of the incus moves inwards at the same time as the handle of the malleus moves inwards, and thus the stapes, which articulates with the incus, is also driven inwards at the same time. But the handle is longer than the process of the incus, so it moves through a further swing than the latter. So also the foot plate of the stapes has a less inward

movement than the handle of the malleus. What the stapes loses in amplitude it gains in force; or as Helmholtz puts it, a motion of great amplitude and little force impinging on the membrane is transformed by the ossicles into one of small amplitude and great force, and communicated through the foramen ovale to the fluid of the labyrinth.

The sound-wave has now arrived at the labyrinth, usually called the sound-perceiving apparatus. But except within the ductus cochlea, the labyrinth is still a sound-conducting apparatus. The wave progresses up the scala vestibuli, passing over Reissner's membrane through the helicotrema, down the scala tympani, and out again into the tympanic cavity by the secondary membrana tympani which closes the round window. This membrane bulges into the drum cavity just as much as the foot plate of the stapes passed inwards, because the fluid in the labyrinth is quite incompressible and is surrounded by hard bony walls. During this passage up one side of the ductus cochlea and down the other, part of the movement is communicated through the thin walls of the duct, and the stiff structures composing the floor of the duct, and included within its lumen, are set into sympathetic vibration, which latter so stimulates the terminations of the auditory nerve distributed amongst these structures, that a sensation of sound is produced.

What exactly takes place within the duct of the cochlea has never been, and probably will never be the subject of direct observation. But the harpsichord or piano theory of Helmholtz is that most commonly held. The basilar membrane with the organ of Corti stretches from one end of the cochlear tube to the other. Near the foramen ovale the stretch of the basilar membrane is very little, and the span of Corti's arches very narrow, whilst towards the helicotrema the whole width of the membrane increases nearly twenty-fold, and the span of the arches of Corti is also much greater. Each radial segment of the membrane, with its supported arch or arches, is supposed to be analogous to the stretched string of the piano or harpsichord, and to vibrate in sympathy with

external sounds just as these instruments do when one sings into them. Sympathetic vibration takes the place of the quill prick or hammer stroke of the instrument as normally sounded. The further elaboration of this theory does not belong to a work on aural surgery; but it may be noticed that since Helmholtz's death one proof of his theory has come to light, which he probably would have regarded as of value. Bezold found in testing the deaf mutes of the Munich Institution, that many of these children have islands of hearing, with deafness for the rest of the scale: hearing for two or three notes, or for half or a whole octave, and deafness for all other notes. This fact, when put along with the other, that *post-mortem* examination of the ears of deaf mutes sometimes shows destruction of parts of the cochlea and preservation of other parts, suggests some such specific use of the segments of the cochlear apparatus as Helmholtz's theory assumes.

CHAPTER III.

DIAGNOSIS AND METHODS OF EXAMINATION.

The Etiology of Ear Disease—The Physiognomy of Ear Disease—Symptoms : Pain, Deafness, Giddiness, Tinnitus—Discharge in Ear Disease—Instruments used in Aural Diagnosis—The Normal Tympanic Membrane—Diagnosis by means of Ventilation of the Middle Ear : Valsalva's Method—Politzer's Method—The Eustachian Catheter—The Auscultatory Signs produced by Ventilation of the Middle Ear—Examination of the Nose and Naso-Pharynx—Tests for Hearing—(*a*) For Acuteness or Acuity of Hearing ; The Limits of Human Hearing ; Tests by a continuous Tone Series ; The Appreciation of Small Differences of Pitch ; (*b*) Tests for the Localization of Disease—Case Sheet for Examination of Patients.

WHEN a case of ear disease comes before the practitioner, the inquiries and observations to be made must proceed on ordinary clinical lines. In addition to these, special tests and methods of examination peculiar to the ear must be used.

During the general examination, the **History of the Ailment** must be noted. In many cases it is difficult to get any date at which the symptoms can be said to have started. This uncertainty is due in many cases to the insidious nature of the symptoms in the early stages—sclerosis, chronic aural catarrh, etc.—or to the fact that the affection is often one-sided, and the healthy ear has carried on the function so thoroughly that the onset of deafness has been unnoticed. Even the length of time during which discharge has lasted is often unknown to a patient, and is thought to be recent, although subsequent examination by the surgeon displays destructive changes of older date. But if the ear symptoms have commenced in a definite acute illness, such as scarlet fever or measles, or are associated with acute nasal or throat symptoms, or if their onset has been accompanied by acute pain, a definite statement as to the date of origin is usually obtainable.

In this connection the *cause* of the symptoms must be sought for. The acute fevers account for a large number of cases of suppurative middle-ear disease; many of these, however, arise from nasal and naso-pharyngeal affections, which latter also give rise to a large number of the suppurative diseases of the middle ear.

Ear diseases or symptoms may arise in the course of almost any *general disease*. Apart from the acute fevers, diphtheria, influenza, syphilis, tuberculosis, Bright's disease, pneumonia, anæmia, leukæmia, and the disorders of pregnancy and lactation, all cause ear symptoms. Rheumatism and gout account for many of the symptoms which appear in middle life, and if two or three members of a family show such symptoms, a *hereditary* predisposition may be assumed to exist, either apart from or co-operating with these tendencies. The similar occurrence of cases of deafness in the young children of a family or family connection, also points to heredity as the cause, whilst the occurrence of isolated cases of deafness in childhood, after hearing but before speech has been developed, should, in the absence of any definite cause, suggest meningitis or other brain affection as the origin.

The *occupation* of the patient should not be forgotten during the examination. Dirty occupations predispose to the formation of ceruminous plugs; noisy occupations to a special form of nervous deafness. *Accident* also figures as a cause of ear disease of old standing. Blows on the side of the head, on the auricle, and on the mastoid, often set up ear diseases. Blows, however, often get credit for symptoms which have existed before their occurrence. The influence of such *drugs* as quinine and the salicylates must be remembered in taking the history of ear symptoms; as also the habits of the patients, especially with regard to the use of alcohol and tobacco.

The *rapidity* or slowness with which the symptoms progress should be noted, after the enquiry as to the possible cause has been exhausted. Sudden deafness may have either a trivial or serious significance; *e.g.*, the influence of sea-water on a ceruminous plug, or the onset of syphilitic disease of the internal ear [illegible]ess

of very gradual onset, unassociated with other prominent symptoms, suggests—if the presence of cerumen be excluded—either chronic aural catarrh or oto-sclerosis.

Deafness which *varies* from time to time, especially with changes in the weather, should direct the examination towards the naso-pharynx.

The history of the case having been unravelled, the physiognomy of the patient should be noted.

The Physiognomy of ear disease is not usually characteristic; but there are two conditions, suffering from either of which the patient sometimes walks into the consulting room so unmistakably "labelled" that the diagnosis can be made at a glance. The first is the dull, stupid, open-mouthed expression of a child whose deafness depends on nasal or naso-pharyngeal obstruction (*Stereogram XLVI*); and the second is the swollen mastoid and projecting auricle—most characteristic when seen from behind—of the patient with a sub-periosteal abscess of the mastoid process (*see Fig.* 50).

Facial paralysis, enlarged periotic glands, and an eczematous state of the incisura intertragica, lobule, and neighbouring parts, characterize tubercular disease of the temporal bone in children, in whom also notched teeth and corneal affections associated with deafness point to hereditary syphilis. Old cicatrices about the face and neck not due to accident, also hint at the tubercular nature of an ear discharge.

The Symptoms of ear disease are chiefly these: (1) *Pain*, spontaneously present or induced by pressure about the auricle or over the mastoid process; (2) *Deafness*; (3) *Giddiness*; (4) *Tinnitus*.

1. When **Pain** is complained of, the presence or absence of discharge should be ascertained. If discharge be present, pressure over the mastoid in search of tenderness there should be tried. Pain when the auricle is moved, is often due to boils of the external auditory canal. If there be no discharge, and if objective examination exclude an acute middle-ear inflammation, a search

should be made in the mouth for bad teeth. In acute inflammations of the middle ear there is a history of pain, suddenly relieved at the period of onset of discharge. In tubercular affections, pain is often absent during the whole course of the disease. In any case of chronic discharge from the ear the sudden onset of pain, with or without the cessation of discharge, points to the retention of the discharge. In acute middle-ear inflammations, before perforation the pain may be very severe, and spread over the whole side of the head, as well as exist in the ear itself. In chronic suppuration the pain is much less violent, or may exist as a slight headache, and it is often necessary to press the mastoid process heavily before the evidence of pain can be brought out.

Pain in the ear is often present in abscess of the tonsil, also in ulcerations of the pharynx near the mouth of the Eustachian tube, and in acute pharyngeal affections.

2. **Deafness as a Symptom in Ear Disease.**—This symptom of ear disease may be present in any degree, and may be due to an affection of the external, middle, or internal ear, or to all of these at once. Its significance will be best understood when the tuning-fork tests are discussed. Even if an apparently sufficient cause for the deafness be found in the external ear, it should be remembered that the real cause may lie in the internal or middle ear.

3. **Giddiness** is a common symptom of ear disease. It is generally due to pressure disturbances within the labyrinth, and may occur during the course of suppurative or non-suppurative diseases of the middle ear. In the former, a spread of the disease to the labyrinth is indicated; in the latter, some sudden change of the air-pressure within the middle ear. In Menière's disease, giddiness is due to a primary labyrinthine affection. It may be due to a foreign body, or a ceruminous plug in the external auditory canal, or to some cause outside the ear altogether.

4. **Tinnitus** in some form is present in many ear diseases. As a temporary symptom it may be present without any special significance, or it may be due to some easily removable cause in the meatus. In neurotic subjects its synchronicity with the pulse-

beat indicates its origin. As a permanent symptom of ear disease it is often very violent and very distressing, and if we exclude acute inflammatory conditions, it points either to the adhesive changes of a chronic aural catarrh, or to oto-sclerosis.

Discharge as an objective sign should always be looked for or enquired about. Its association with pain has been referred to. It must not be looked upon as a separate disease, but as the evidence of one of various conditions. It may come from an eczema of the canal; or from a boil within the canal, but its commonest source is the middle ear. It may be mixed with blood (granulation masses), or with epithelial masses (cholesteatoma), or with bone-grit (caries). It must always—if it come from the middle ear at all—be looked upon as evidence of a disease which is a menace to the life of the patient. Discharge which is mixed with mucus comes, of course, from the middle ear. The odour of the discharge should be noted.

INSTRUMENTS.

The following instruments are used in aural diagnosis. Several of them require special notice :—

Forehead mirror or reflector.

Specula of various sizes.

Straight and bent probes.

Cotton holders with screwed or roughened tips.

Aural forceps.

A set of Eustachian catheters and air-bag for inflating the middle ear, also a set of Eustachian bougies.

A diagnostic tube (rubber with bone ends).

A nasal speculum and a tongue depressor.

A Seigle's pneumatic speculum

Several aural syringes.

A set of tuning-forks of various pitches.

A Galton's whistle.

Sources of Light.—A good circular Argand gas burner enclosed in a glass funnel is a sufficient source of light, but a metal funnel with a lens directed towards the observer is often used. (*Fig.* 3.)

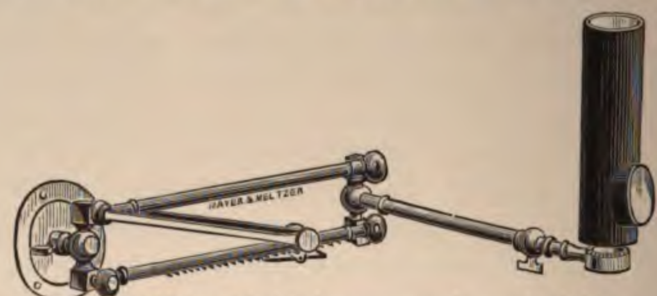


Fig. 3.—Mackenzie's Rack-movement Lamp for Wall.

An ordinary large gas flame, if fixed on a bracket which can be brought to about the level of the patient's head, will do if the examination must be made in his own house, or an oil lamp can be made to serve the purpose admirably. If the surgeon have accumulators at hand, a small lamp may be fixed in the head-band round the forehead, and the examination conducted by direct light. Electric light, either direct or reflected, has no advantage over gas or oil. Indeed, the best light of all is reflected daylight, but this, in winter especially, and in large cities, is seldom available. A convenient electric lamp, lighted from the street main, is shown in *Fig.* 4.

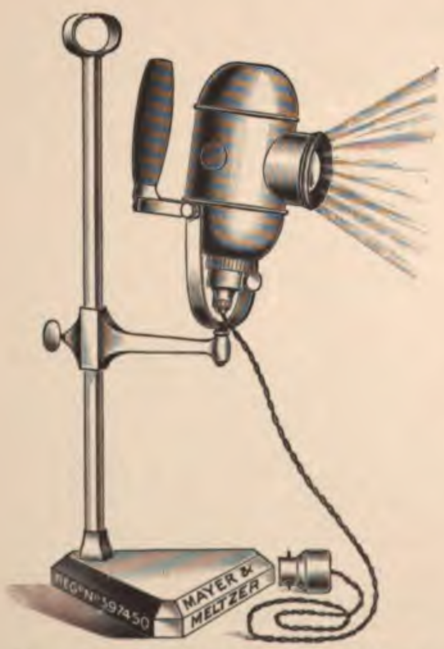


Fig. 4.—McDonald's Table or Hand Lamp.

The Mirror and Speculum.—It is assumed that the surgeon has first of all examined the ear

by what direct light is present in the consulting-room, before resorting to these. In this way affections of the auricle—tumours and skin affections, etc.—will be seen, and if he have pulled the auricle backwards and upwards so as to straighten the canal, the contents of the latter, or, if its lumen be wide and clear of obstruction, the membrana tympani, will be visible. Excessive discharge from the middle ear will thus often be seen, either running from the orifice of the canal or filling its calibre. But in most cases the mirror and speculum will be required to get a good view of the deeper parts.

Fig. 5.—Forehead Mirror. *Fig.* 6.—Hand Mirror.

The forehead mirror (*Fig.* 5) should be at least 3 inches in diameter, slightly concave, and with a hole in its centre about $\frac{3}{8}$ inch in diameter to correspond with the pupil of the surgeon, who in most cases looks through the centre of his reflector. With the mirror fixed on the forehead, both hands are free for manipulations within or about the ear. This object is also attained by fixing the mirror to a rubber-covered bar which is held between the teeth, and which is fixed at right angles to the mirror.

For examination in cases where manipulations are unnecessary a hand mirror may be used (*Fig.* 6).

The Speculum.—Aural specula should be of various sizes, and the narrow end may be either oval or circular (*Figs.* 7—9). For children, and for adults in whom the canal is either naturally narrow or has become so from thickening of its walls, very small specula may be necessary. It is easy to use an aural speculum, but generally the beginner fails for a few times at first to get a view of the membrana tympani, even in a normal case. The auricle should

Fig 7. *Fig.* 8. *Fig.* 9.

Various Forms of Aural Specula.

be pulled upwards and backwards, the direction of the outer end of the canal ascertained, and the narrow end of the speculum pushed in until the instrument is engaged or caught by the meatal walls. These walls are passive, of course, but the speculum will generally remain in position, even if the surgeon cease to hold it. If the membrane cannot be seen when the above manœuvre has been performed, the head of the patient should be sloped away from the surgeon, for very often the direction of the canal is a good deal upwards as well as inwards and backwards (*see* p. 10). If the

beam of light from the reflector has been well shot into the speculum, the tympanic membrane will come into view. One or two very wide specula are useful for intra-tympanic surgery.

EXAMINATION OF THE TYMPANIC MEMBRANE.

The *normal* membrane (*Fig.* 1, p. 22, also *Plate III*, *Figs.* A, B), has a grey or greyish-blue look. It has been called slate-coloured, or like a piece of parchment. It is semi-transparent: through it can be seen some of the tympanic contents. Of these the handle of the malleus is constant, the long process of the incus occasional. Sometimes also the promontory can be seen. The malleus handle stretches from near the margin of the membrane above, downwards and slightly backwards, to near the centre of the membrane, where it terminates as the umbo at the apex of the wide cone formed by the slightly concave surface of the membrane. From the tip of the handle—umbo—stretching downwards and forwards towards the inferior border of the membrane, is the triangular spot or cone of light. This is a reflex appearance, which is absent in many cases of disease of the membrane. At the upper end of the handle, near the antero-superior border, is the short process of the malleus, seen as a nipple-shaped projection, and above and in front of the short process is the triangular area, depressed and looser than the rest of the membrane, known as Shrapnell's membrane. The normal slope of the membrane is from above and behind, downwards and forwards, for the anterior wall of the external auditory canal is longer than the posterior, and the floor is longer than the roof.

The membrane may vary in appearance from the normal, in colour, lustre, and curve. The slightest irritation in the canal—for instance, the introduction of the speculum—will make it blush; syringing does the same. The use of a probe in removing a flake of epidermis or cerumen causes immediate reddening. Inflammations of its structure redden and dull its surface. Pus in the middle ear may bulge it at various parts. Alterations in the air-pressure of the middle ear generally suck it in, causing in time

permanent depressions, pits, and folds in it. Sudden increase of air-pressure, as after the use of the air-bag, may balloon it in places, especially if it has been previously thinned by chronic changes. Most diseased processes, either in the middle ear or in the external auditory canal, thicken it if they be long continued, and calcareous masses in its substance give it a white porcelain-like appearance in places. Healed cicatrices give rise to pits and special light reflexes in the membrane (*Plates III* and *IV*).

Fig. 10.—Seigle's Pneumatic Speculum.

Siegle's Speculum.—The motility of the tympanic membrane can be demonstrated by a Siegle's pneumatic or suction speculum (*Fig.* 10), the air-pressure within the external auditory canal being varied either through a tube passing to the mouth of the surgeon or to a compressible air-ball held in the hand. The chief zone of movement is in the upper and back part of the membrane, and along with this section the handle of the malleus is seen to move through a considerable arc, the centre of which is at the short process and the periphery at the umbo. During the application of vibratory massage by a Breitung's pump, this zone and the malleus handle are seen to go through these movements with great freedom. The movements are often limited or prevented by adhesions within the drum cavity. Thickening or scarring of the substance of the drum membrane may also limit its movements.

Fig. 11.—Aural Forceps.

For the manipulation of small pieces of cotton within the meatus and drum cavity, and for the removal of solid pieces of cerumen and epidermis, the examiner must have a set of bent *aural forceps* (*Fig.* 11) and a set of cotton holders. Simplicity should mark the plan of these two instruments.

The best aural forceps are set at an obtuse angle, have fine enough tips to open within the lumen of a moderately-sized speculum, and have no joints. They are kept apart at the tips by the set given to the blades at their junction with the handle. The roughening usually given to the sides of the handles is bad, the grooves harbouring dirt and rust.

Cotton holders should be of tinned iron wire, which can be bent to any set so as to suit the purpose of the surgeon. Both ends should be roughened or screwed so as to hold the tips of cotton firmly. The cotton should be fixed to the tip so as to cover the end of the wire completely, and the end of the tip itself should be loose and fluffy, so as not to hurt the patient, and in order to take up as much discharge as possible. A bulbous or thick waist given to the tip obstructs the view of the surgeon. The tips should not be too large; they must enter the speculum and pass into the inner end of the meatus without jostling the sides.

Fig. 12.—Aural Syringe.

The best *aural syringe* (*Fig.* 12) for use by the surgeon, must have: (*a*) A long, narrow, straight nozzle without a markedly bulbous tip, which can be introduced into the external auditory canal and moved therein so as to alter the direction of the current of fluid, but without the tip of the nozzle impinging on the walls of the canal; (*b*) A thumb ring and a pair of side rings, a projecting flange, or a double crutch for the fore and middle fingers of the surgeon's right hand. Without some such provision the fingers will slip when the surgeon is using alkaline solutions, and the tip of the syringe will be driven forcibly into the middle ear. (*c*) It must be large enough to contain two or three ounces of fluid. The syringe may

be made of glass with metal fittings, or it may be made entirely of metal, but it must be so constructed that it can be taken apart and the parts boiled. The metal parts should be plated.

The syringe should never be used in the ear without previous inspection of the canal with the help of mirror and speculum, and the current of fluid should never be sent forcibly against a bare tympanic membrane, or into the middle ear after all discharge has been removed.

A smaller syringe for patient's use is represented in *Fig.* 13. It is made of glass with vulcanite fittings, and holds nearly two ounces of fluid.

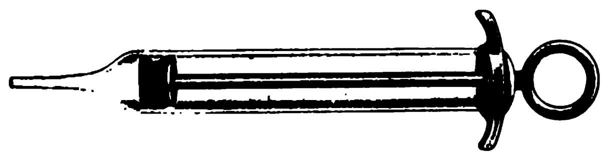


Fig. 13. Syringe for Patient's use.

Of great importance in the diagnosis of affections of the external auditory canal, tympanic membrane, and middle ear, are sets of straight and bent *probes*. In one class of cases—chronic suppuration with caries—the probe is of greater importance than the speculum, for it strikes the bare internal tympanic wall, the necrosed ossicle, or other diseased spot of bone. The probe should, however, only be used after careful inspection and cleansing of *débris* from the middle ear. The bent probes have their distal ends turned at right angles to the stem—one-eighth to half an inch—and are used for ascertaining the condition of the attic, the antrum, the Eustachian tube, and the tympanic cellar. They should be made of copper (plated), so that they bend easily without breaking. Probes are also useful in the diagnosis of cerumen, foreign bodies, and in the location of the attachment of polypi.

EXAMINATION OF THE MIDDLE EAR.

There are three methods by which the state of the middle ear may be ascertained, and the permeability of the Eustachian

tube tested. These are: (1) *Valsalva's* method; (2) *Politzer's* method; and (3) The method by use of the *Eustachian catheter*. All these methods are also methods of treatment, and occupy an important place in the practice of aural surgery.

1. **Valsalva's Method** (introduction of air into the middle ear during forcible expiration with the mouth and nostrils closed). Hartmann states that a pressure equal to 20–40 mm. of mercury is necessary in the naso-pharynx to force air into the middle ear during Valsalva's experiment, when the muscles of swallowing are passive. As the average pressure which can be produced by an adult by forced expiration is equal to 100 mm. of mercury, it follows that with normal conditions it is easy to inflate the middle ear by this method. When there is much swelling of the mouth or walls of the tube, or when the patient's expiratory power is weak, this method is insufficient for the forcing of air into the middle ear, but when the resistance in the tube is slight, the method is sufficient. In suppurative middle-ear disease, where the tube (although primarily affected) has returned to nearly its normal state, the method is very valuable, both for diagnosis and for clearing of the middle ear of purulent contents, and to assist in drying the ear of the lotions which have been used for cleansing.

2. **Politzer's Method.**—In 1863 Politzer discovered a method of ventilating the middle ear which has since been extensively used, and which still (though to a less extent) is used both in the diagnosis and treatment of ear disease. The more thorough treatment by operation of the naso-pharyngeal affections of children (adenoids, etc.) has rendered the routine treatment by Politzer's method of non-suppurative cases in children less necessary, but it still retains its original value in diagnosis, and has an important place as a means of treatment in both suppurative and non-suppurative ear disease. Its author would have gained a permanent place as a pioneer in aural surgery for this discovery, even had no other part of his great work been done. The method takes advantage of the fact that during the act of swallowing the most favourable conditions for the entrance of air into the middle

ear by the Eustachian tube exist. The naso-pharynx is then shut off from the parts below by the application of the soft palate to the posterior wall of the pharynx, and if at this moment the anterior nares be also closed, and a quantity of air be forced from the nose into the naso-pharynx, the ventilation of the middle ear is in most cases accomplished.

Politzer's method of ventilating the middle ear is carried out as follows: An 8- or 10-ounce pear-shaped rubber bottle is fitted with a vulcanite tip, to which a short, stout, rubber tube about six inches long is attached (*Fig.* 14). Into the end of this rubber tube is fixed an olive-shaped nozzle of sufficient size to fill one of the anterior nares of the patient to be operated upon. This nozzle is fixed in position and held there by the forefinger and thumb of the surgeon's left hand, another of the surgeon's fingers crossing the tip of the nose and occluding the other nostril. The air-bag is held within the palm of the surgeon's right hand ready for compression. A sip of water taken by the patient before the insertion of the nozzle, and held in the mouth in the meantime, at a pre-arranged sign or word is swallowed, and simultaneously the air-bag is compressed. The air-pressure required for the execution of this method is said by its author to be 0·1 to 0·4 of an atmosphere. The larger the bag and the better fitting the nose-piece, the better will be the air-pressure, but the bag must not be too large for the grasp of the surgeon's hand. The current should be directed along the inferior meatus of the nose, rather than in an upward and backward direction.

Fig. 14.—Politzer's Air-bag.

Unless the bag be compressed at the proper moment, the air

will not enter the middle ear. The best guide for the surgeon, if he cannot rely on the co-operation of the patient at the arranged instant, is to watch the rise of the thyroid cartilage during the act of swallowing, and time his compression to suit the movement. The swallowing of water is not necessary during the operation of Politzerization. During the utterance of any monosyllable ending in the letter *k*, such as *hook*, *hock*, compression of the air-bag will have the same effect, and in children this simplifies the procedure; but in many cases the naso-pharyngeal air-pressure is not sufficiently raised to effect opening of the tubes unless an act of swallowing have been performed. The olive should be withdrawn from the nostril before the hand compressing the bag is relaxed, else air and discharge from the nostril will be sucked back into the bag.

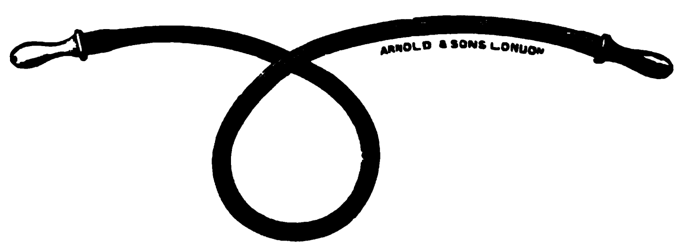


Fig. 15.—Auscultation Tube.

The arrival of the air in the middle ear is intimated to the patient in most cases by a feeling of fulness and cracking, although successful inflation may take place without any such sensations. To the surgeon success is intimated in various ways. If he be provided with an auscultation tube (*Fig.* 15) the movement of the membrane and the occurrence of râles within the Eustachian tube may be heard, and have to be distinguished from sounds produced in the throat by the act of swallowing. After the inflation, inspection by mirror and speculum may show alterations in the tympanic membrane due to inflation (bulging, etc.).

Catheterization of the Eustachian Tube.—The introduction of a catheter through the nose into the Eustachian tube is not

difficult. The catheter used should be 4 to 6 inches long, should be curved at the tip, and should be provided with a ring fixed at its end on the same side of the catheter as the concavity near the tip. Catheters may be made either of metal (*Fig.* 16) or vulcanite (*Fig.* 17), the former having the advantage that they can be boiled. Several sizes, with variously curved tips, should be at the disposal of the surgeon.

Fig. 16.—Silver Eustachian Catheter.

During the introduction of the instrument the tip of the nose should be raised by the left thumb of the surgeon, whilst the fingers of the same hand rest on the patient's forehead and steady him. The tip of the catheter is now passed into the nose of the patient with the curve downwards, and the right hand of the surgeon is gradually raised to the horizontal as the tip enters the anterior nares. The tip is now made to travel along the floor of the nose as near its junction with the septum as possible, and if no obstruction

Fig. 17. Vulcanite Eustachian Catheter.

[illegible] this course is pursued till the catheter tip impinges on the [illegible]tant but elastic posterior pharyngeal wall. One of two courses [illegible] now be followed:

[illegible] The tip may be turned inwards towards the other side [illegible] nose, and withdrawn till the curve of the catheter hitch [illegible] the posterior border of the nasal septum. If now the [illegible] be rotated through a full half-circle, the tip enters the [illegible] the Eustachian tube. That the catheter is in position [illegible]ined by blowing through it with the air-bag, the auscul[illegible] meanwhile connecting the external auditory canals of

the patient and surgeon. Should the catheter prove not to have entered the mouth of the tube, its tip must be moved a little forwards or backwards till it is felt to slip into the mouth of the tube.

2. The second method is to search for the opening of the tube without previously bringing the concavity of the catheter against the nasal septum. The catheter having reached the posterior pharyngeal wall, its tip is rotated outwards and pulled along the outer pharyngeal wall till it is felt to pass the posterior lip of the tube and enter its mouth. A little further rotation now brings the axis of the lumen of the catheter into that of the Eustachian tube, a result which is usually attained when the ring of the catheter points to the outer canthus of the eye of the same side. The ring of the catheter sometimes points a good deal lower than the canthus of the eye when its tip enters the mouth of the tube.

Projections of the nasal septum and enlargement of the opposite inferior turbinated body, make all rules about the introduction of the catheter useless in some cases. Just as in the case of the urethral catheter, its progress must be guided by the shape of the canal, and by the kind of obstruction with which it meets. The educated hand adapts its movements to the peculiarities of each case, and only very occasionally does the practitioner fail to reach the pharynx. Once the tip is in the pharynx the chief difficulty is over (*Stereograms LII, LIII, LIV*). When one side of the nose is so narrow or so tortuous that no catheter may penetrate to the naso-pharynx, it is usually easy to enter both Eustachian tubes from the more open side.

When the catheter tip returns tinged with blood, either the tip has excoriated an already ulcerated surface, or has punctured a sound surface. Inflation through such a surface may cause emphysema of the tissues of the side of the neck. Such an accident is not serious, the effects soon passing away; but it need hardly ever happen to the operator who is careful to ascertain that the tip of the catheter is really in the mouth of the Eustachian tube.

The relative values of these methods of ventilating the

middle ear during diagnosis should be appreciated. Valsalva's method often fails where there is swelling of the mouth or narrowing of the lumen of the Eustachian tube. The catheter is useless in young children, who will not tolerate the manipulations in the nose. Even in adults the nasal manipulations often cause nervousness, although there is hardly ever actual pain where the inferior meatus is of fair width and not too tortuous. Politzerization is really as disagreeable to most patients as catheterization, but is much quicker, and consequently better borne. On the other hand, catheterization is much safer in certain cases. There is less risk of carrying loose infective material into the middle ear than when the air-bag is used by Politzer's method. Then the affected ear can be ventilated by the catheter without air being sent into the sound ear, whereas both ears are inflated by Politzer's method, though the current be sent in by but one nostril. Its author claims for Politzerization that in many cases it is superior to catheterization; that a higher, although momentary, air-pressure is got by his method, and sometimes a greater improvement in hearing results than after the use of the catheter. He further points out that it is simpler, more easily applied to children and nervous patients, and that it can be carried out by the patient himself when its continued use as a therapeutic agent is required. But he admits that it sometimes fails when the catheter succeeds, and that for the injection of fluids into the middle ear, catheterization is the better method. Sometimes during Politzerization air is forced into the stomach, and gives rise to pain and distension.

Auscultatory Sounds heard during Ventilation of the Middle Ear.—When air is blown through the catheter and a normal Eustachian tube into the middle ear, the sound heard by the surgeon through the auscultation tube is that of a dry, open current of air. If swallowing be practised during catheterization, the air enters more freely. The volume, loudness, and pitch of this current of air depends on the width of the lumen of the tube, the size of the catheter used, the thoroughness with which the tip of the catheter fits the mouth of the tube, and the presence or absence

of a perforation in the tympanic membrane. When the lumen of the tube is narrowed by stricture, and when the tube or middle ear contains fluid, the sounds heard are altered accordingly. Stricture gives rise to a thin, high-pitched, hissing sound. Mucus or any fluid causes râles to be added to the auscultation sounds. If the fluid be very tenacious and small in quantity—indeed a semi-fluid—no râle is heard, and in those cases in which the secretion in the middle ear has become organized into fibrous tissue, the auscultation sounds are those of the normal ear. In moist conditions of the tube, râles are often produced by the first compressions of the air-bag, the later compressions giving a clear, dry sound. In this case mucus has been dislodged from the vicinity of the catheter tip, and removed further up the tube or into the naso-pharynx. When the catheter lies in the naso-pharynx outside the tube, compression of the bag may give rise to abundant râles of a large character; but they seem far away to the ear of the surgeon when compared with those produced in the tube, or in fluid within the middle ear.

For the examination of recesses beyond the tympanic ring (attic, aditus, etc.) a small *intra-tympanic mirror* is often found useful. The simplest form of the instrument is shown in *Fig.* 18.

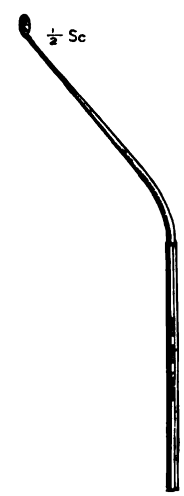


Fig. 18.—Botey's Intra-tympanic Mirror.

EXAMINATION OF NOSE AND NASO-PHARYNX.

For the examination of the anterior nares, a Hartmann's or Kramer's *nasal speculum* (*Fig.* 19) should be used to dilate the soft parts, when with a good light the condition of the turbinated bodies, the width of the nasal passages, the presence of spurs or of other projections from the nasal septum, and the departures of the outlines of the latter from the vertical, can be noted. Nasal polypi will thus come into view. If a good view cannot be got by this means, the soft tissues should be shrivelled by the application of a solution of hydrochlorate of cocaine or adrenalin, when a

satisfactory view will be got. The posterior nares may be examined by posterior rhinoscopy, or the forefinger may be quickly inserted through the mouth, behind the soft palate into the vault of the pharynx, and forward into the posterior nares. The digital method is the only one possible with children, and the quickest and easiest even in adults.

Much information can thus be got in a surprisingly short space of time. Adenoid growths, enlargement of the posterior ends of the inferior turbinated bodies, polypi, and other obstructive conditions, can be thus quickly and certainly diagnosed. The examination is disagreeable rather than painful. If adenoid vegetations be present, bleeding will take place into the mouth; but it is always slight, and never lasts more than a second or two.

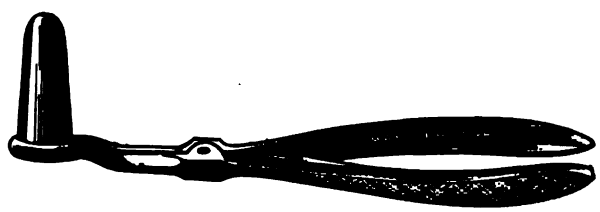


Fig. 19.—Nasal Speculum.

With the help of a tongue depressor the presence of enlarged tonsils and of diseased conditions of the posterior pharyngeal wall can be discovered.

If *anterior rhinoscopy* be used, the position of the septum is carefully observed, and any deviation from the normal noted. The inferior turbinated body should be followed from before backwards by the eye of the surgeon, until its whole length has been seen. The probe may be applied to its edges, so that the relation of their soft borders to the underlying bone may be made out. The middle turbinated body should next be examined, and the nature of any hypertrophy which exists should be made out by the help of the probe, applied *before*, and then *after*, the use of cocaine or adrenalin. Any purulent discharge coming from about

the middle turbinated body, will necessitate a further examination of the sinuses of the face—maxillary, ethmoidal, frontal, or sphenoidal.

Posterior rhinoscopy is much more difficult than the examination by the anterior nares. A small mirror (*Fig.* 20) similar to a laryngeal mirror, is used for the examination. It is inserted behind the uvula, the tongue of the patient being kept down by a tongue depressor, whilst the patient breathes by the nose and thus allows the palate to become flaccid. The mirror has its plane so adjusted by the surgeon that a view of the parts within the posterior nares is obtained. These are: The posterior border of the septum nasi separating the posterior nares, the posterior ends of the three turbinated bodies and the intervening meatuses, the roof of the naso-pharynx, the lateral walls of the naso-pharynx, and the mouth of the Eustachian tube on each side.

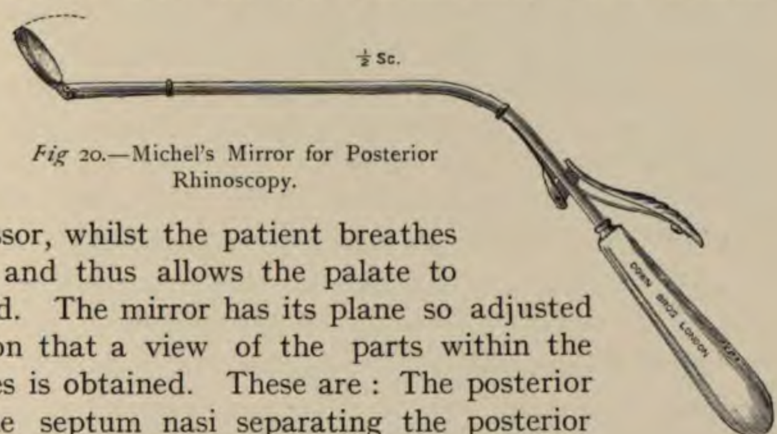


Fig 20.—Michel's Mirror for Posterior Rhinoscopy.

For the removal of crusts and discharge which make thorough examination of the nose difficult, some kind of *nasal douche* is necessary. The douche is used more extensively in the treatment than in the diagnosis of intra-nasal disease, and its principle will be referred to later (*Fig.* 21).

Fig. 21.—Nasal Douche.

It is hardly necessary to point out that aural instruments should be carefully kept and regularly cleansed. A large number of specula should be at the command of the surgeon, and

no speculum should be used for a second ear without being boiled. Silver specula are the best, unless for the application of caustics, when vulcanite instruments should be used. Probes should be treated like specula, so also should the nozzles of metal syringes. Eustachian catheters must be similarly sterilized, but vulcanite catheters cannot be boiled without their curves being undone. Vulcanite catheters must be washed through by the help of the syringe with weak soda solution, and then steeped in carbolic lotion. Cotton-holders are most rapidly sterilized by passing their ends through the flame of a spirit lamp. In time the flame smooths their roughened ends and makes these too sharp, but even a cheap cotton-holder lasts a long time before this takes place, and the flame sterilization is very rapid and thorough.

TESTS FOR HEARING.

TESTS for hearing have two objects: I.—To ascertain the *acuteness* of hearing, or the degree of deafness, if the latter exist. II.—To *localize* the diseased conditions on which any deafness which is present depends.

Tests used with the first object in view set up a sound of standard intensity, which should be heard at a given distance by a normal ear. This is the kind of test most commonly used in clinical work for ascertaining the acuity of hearing. But as sounds differ from each other in pitch as well as intensity, tests have to be used for the range of hearing (highest and lowest audible notes) and for the appreciation of small differences of pitch. These tests are all applied at a distance from the ear, *i.e.*, they are aerial tests.

Tests used with the second object in view, that of localizing diseased conditions, are partly aerial and partly immediate in their application. In the immediate tests, the sounding body is connected with or pressed against some part of the skull, no air distance intervening. The tuning-fork is the chief test thus applied, and is indeed by far the most important aid we have in localizing the disease which causes deafness.

I.—Acuity of Hearing.

The human voice, the tick of a watch, the various forms of acoumeters and metronomes, and other like instruments, are used for testing the acuity of hearing.

The sounds of the voice are necessarily the most important of such tests, for the commonest practical use to which the human ear is put is to distinguish the sounds of the voice. According to the degree of deafness present, the voice may be used either as whispering, in conversational tones, or as loud shouting. Such tests can never of course be absolute, for there is no standard strength of voice, nor is any observer able always to speak with the same intensity; but the voice has the great advantage of being a many-toned test, and with an organ of such an enormous range as the ear, no single-toned test is really of very great value. Voice tests have to be often repeated by the same observer, and carefully checked, before any inference can be based on them.

Vowels are much better heard than consonants, and some vowels better than others. It is therefore common in high degrees of deafness to have the vowels recognized and the consonants mistaken. In the highest degrees of deafness, *e.g.*, amongst deaf-mutes, the vowels A and O are often recognized when the others are mistaken. Both consonants and vowels are more easily made out than sentences, unless where the sense of the context suggests what the words should be. In giving test words or phrases, it is better to give unconnected elements such as the numerals 4, 9, 1, or the words Robert, Thursday, January; the same words or numbers should not be repeated, but as much variety as possible used in giving the tests.

The ears should be tested separately, the ear not under observation being firmly plugged by the forefinger of the patient or that of an assistant; and as all deaf people lip-read to a great extent, the face of the patient must be turned away from that of the surgeon, or if both ears are being tested together, the patient should face the surgeon and look to the ground.

but for use in the consulting-room a smaller instrument of more limited range can easily be made. If two such notes be sounded one after the other, of nearly the same pitch, the opinion of a listener can always be corrected by sounding the notes together and noting the beating of the tones. A difference of half a vibration, or one beat in two seconds, can be accurately measured, the value of this in the fraction of a semi-tone varying, of course, with the position of the notes in the musical scale.

With this instrument the author has tested about 200 persons of all ages and of all degrees of musical attainment. Non-musical or miscellaneous companies generally had their capacity for appreciation severely taxed by intervals of $\frac{1}{30}$ or $\frac{1}{40}$ of a semi-tone. Many made mistakes at $\frac{1}{8}$ of a semi-tone. Mistakes were oftener made with flattened than with sharpened intervals. On the other hand, pianists, tuners, violinists, and other experts often recognized $\frac{1}{64}$ and even $\frac{1}{80}$ of a semi-tone, but failed at smaller intervals. These last intervals in the middle parts of the musical scale represent a half to one vibration. Many musicians showed a sensitiveness for the octave almost equal to that for unisons. At a considerable distance comes sensitiveness for the fifth, and at a much greater distance that for the fourth, the major third, and major sixth.

II.—Tests for Localization.

Most of the tests used for localization of the diseases on which deafness depends are based on our knowledge of the fact that sound is conducted by solids as well as through the air. A vibrating tuning-fork, therefore, placed with its stem against the patient's skull, is heard independently of aerial conduction. This is known as *bone conduction*. In the normal ear, air and bone conduction have a definite relationship, and this latter is disturbed when the sound-conducting arrangements are diseased on the one hand, or when, on the other hand, there is disease, of the sound-perceiving apparatus.

Tuning-forks used for localization purposes should be fairly large, of moderate pitch, and so loaded that they vibrate as long

of the same metal is made to fall through a definite distance. Both the cylinder and the hammer are supported on a vulcanite upright, the ends of which are made concave for the reception of the thumb and finger. The distance through which the hammer falls is limited by its end nearest the hand coming in contact with a check which projects from the upright. The sound produced is like the tick of a very loud watch. The fall of the hammer gives a more resonant metallic click, which under favourable conditions can be heard by a normal ear at a distance of 15 metres.

For testing the bone conduction, a pin is fixed to the upright. This pin has a flat metal disc at its end, and this can be applied to the mastoid process or other part of the skull.

For testing aerial hearing in cases where the acoumeter is not heard, a metronome may be used.

Having fixed the normal hearing-distance of any test, say voice, whispered speech, watch, or acoumeter, it is convenient to have some means of representing the result in cases of deafness.

If the surgeon's watch be heard by a normal ear at 36 inches, this may be made the denominator of a fraction, normal hearing being represented as $\frac{36}{36}$. If the patient hears the same watch at 18 inches, this is made the numerator of a similar fraction, and his hearing distance represented as $\frac{18}{36}$. Similarly, if the acoumeter have a hearing value of 15 metres, and the patient hear it at 3 metres, his hearing power for this test is $\frac{3}{15}$.

But a clear idea must be held as to the meaning of such fractions. They are *not per-centages*. The man who hears the watch at 18 inches only, cannot be said to have lost exactly 50 per cent of his hearing. He has lost really much more, for sound diminishes in intensity as the *square* of the distance, not directly as the distance. It is quite true that any mathematical statement of such results is rendered incorrect by the fact that tests are usually applied in small rooms, where reflection of sound interferes with the rigid application of the law of inverse squares, but it is also true that the results of hearing tests are usually stated by writers as if such a law were entirely non-existent.

In applying these tests it is also necessary to remember that the axis of best hearing is not at right angles to the side of the head, but at right angles to the floor of the concha, the collecting cup in the auricle; and therefore, a watch or other test instrument is best heard when held downwards and forwards from the side of the head, instead of outwards at right angles to the side of the head.

For shy children, who will neither repeat test numbers nor give any statement about the tick of a watch, the writer often adopts a method the results of which cannot be stated arithmetically, but which is very convenient, and which generally at once demonstrates the degree of deafness, or the fact that improvement has resulted from ventilation of the middle ear. The child is sent to the farthest corner of the consulting-room, with his face turned away from the surgeon, and with instructions that whenever a tap is heard he is to turn round. The surgeon then gives taps with his finger-nail of different strengths to various objects—chair, table, etc.—and may thus elicit evidence of hearing which he has otherwise failed to find. A little practice enables the surgeon roughly to measure these results.

High and Low Notes.—Hearing tests have to be applied for both *very high* and *very low* notes. In certain classes of cases—diseases of the sound-conducting apparatus—the hearing for high tones is preserved, whilst that for low tones disappears. In diseases of the auditory nerve the converse is the case. Further, in many cases of deaf-mutism, gaps in the hearing are found to exist; or, rather, *islands of hearing* in the surrounding sea of deafness can be mapped out (Bezold). So that a *continuous tone-series* of some kind is required for the complete examination of the auditory nerve. Experiments by Preyer, Helmholtz, etc., seem to show that in a normal ear the lower limit of hearing is somewhere between 15 and 30 vibrations per second. Preyer used large forks and reeds; Helmholtz large organ pipes, forks, and stretched strings. For clinical purposes the largest forks in Bezold's continuous tone-series are reliable.

From the lower limit, human hearing extends uninterruptedly up to between 40,000 and 50,000 vibrations per second—an enormous range when compared with such an organ as the eye; because from the red to the violet the vibration number is only doubled, so that the range of the eye for light is only one octave.

Some people with otherwise normal hearing, and with acute musical ears, show deafness to high notes. Tyndall describes a case of a friend of his own who heard nothing of the shrill insect music caused by crickets, etc., which rent the air in the Alps. The writer has recorded a case in a man with a good musical ear, and otherwise normal hearing, who heard nothing of any sound higher than 5,280 vibrations. But apart from such exceptional cases, the failure to hear high notes must be considered as pathological, and is almost always accompanied by other evidences of a diseased condition of the internal ear. Chladni, Wollaston, Despretz, Appun, and Preyer have all attempted to fix the upper limit of human hearing, using forks, steel rods, sirens, and other instruments; but the most convenient instrument for this purpose is the *whistle* of Mr. Francis Galton, which for clinical purposes is quite satisfactory. This instrument consists of a very small brass tube of fine bore provided with a movable piston by which to vary the pitch, the sound itself being produced by the compression of a small rubber bag. The modification of Galton's whistle by Edelmann, and known as the Edelmann-Galton *pfeife*, gives stronger notes than the original instrument, and as these notes are capable of fairly accurate measurement, it is the best instrument for use in the consulting-room (*Fig.* 23).

Mr. Galton, in his *Enquiry into Human Faculty*, says: "On testing different persons, I found there was a remarkable falling off in the power of hearing high notes as age advanced. The persons themselves were quite unconscious of their deficiency, so long as their sense of hearing low notes remained unimpaired. It is an only too amusing experiment to test a party of persons of various ages, including some rather elderly and self-satisfied personages. They are indignant at being thought deficient in the

power of hearing, yet the experiment quickly shows that they are absolutely deaf to shrill notes which younger persons hear acutely, and they commonly betray much dislike to the discovery. Every one has his limit, and the limit at which sounds become too shrill to be audible to any particular person can be quickly determined by this little instrument. Lord Rayleigh and others have found

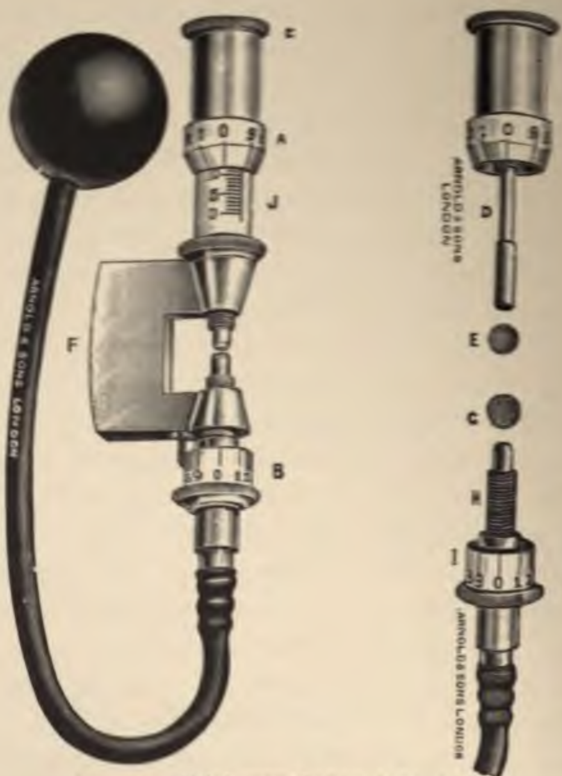


Fig. 23.—Edelmann-Galton Whistle.

that sensitive flames are powerfully affected by the vibrations of whistles that are too rapid to be audible to ordinary ears. I have tried the experiment with all kinds of animals on their power of hearing shrill notes. I have gone through the whole Zoological Gardens using an apparatus for the purpose. It consists of a

walking stick that is in reality a long tube. It has a bit of india-rubber pipe under the handle, a sudden squeeze on which forces a little sound. I hold the stick as near as is safe to the ears of the animals, and when they are quite accustomed to its presence and heedless of it, I make it sound. Then if they prick their ears it shows they hear the whistle. If they do not, it is probably inaudible to them. Still, it is very possible that in some cases they hear but do not heed the sound. Of all creatures, I have found none superior to cats in their power of hearing shrill notes. It is perfectly remarkable what a faculty they have in this way. Cats, of course, have to deal in the dark with mice and to find them out by their squeaks. Many people cannot hear the shrill squeak of a mouse. Some time ago, singing mice were exhibited in London, and of the people who went to hear them, some could hear nothing while others could hear a little, and others, again, could hear much. Cats are differentiated by natural selection until they have the power of hearing all the high notes made by mice and other little creatures they have to catch. A cat that is at a very considerable distance can be made to turn its ear round by sounding a note that is too shrill to be audible by almost any human ear." Mr. Galton also found that small dogs heard much higher notes than large ones.

In some cases of deafness it is enough to ascertain the hearing acuity for a sound of one pitch, say that of a watch, an acoumeter, or of the human voice. But there are many cases in which a more exhaustive examination is necessary. Such are those in which the results at various pitches contradict each other, or in which they are positive at one part of the scale and negative at another. Where the deafness is due to a mixed condition—disease in both the sound-conducting and the sound-perceiving apparatus—the results at various pitches seem to contradict. Where entire destruction of part of the sound-perceiving apparatus has taken place, the tests may be positive at one or more pitches and negative at others. Such cases make the possession of a continuous tone-series of importance to the practitioner. It is probable that testing by

such an elaborate apparatus will never become the rule in every case of deafness; the apparatus is costly, and its thorough application involves the spending of much time. But it is quite certain that for special cases testing by a continuous tone-series will be much more used than it is at present.

As there seems to be a good deal of looseness in the minds of practitioners about the pitch of the notes referred to as hearing-tests, the following table is annexed for reference:—

PITCH OF NOTES.

	32-ft. Octave. $C_{II} - B_{II}$ Sub-contra.	16-ft. Octave. $C_{I} - B$ Contra.	8-ft. Octave. $C - B$ Great.	4-ft. Octave. $c - b$ Unaccented.	2 ft. Octave. $c^{I} - b^{I}$ Once accented.	1-ft. Octave. $c^{II} - b^{II}$ Twice accent'd
C	16	32	64	128	256	512
D	18	36	72	144	288	576
E	20	40	80	160	320	640
F	21·3	42·6	85·2	170·4	340·8	681·6
G	24	48	96	192	384	768
A	26·6	53·2	106·4	212·8	425·6	851·2
B	30	60	120	240	480	960

	½-ft. Octave. $c^{III} - b^{III}$ Three Times Accented.	¼-ft. Octave. $c^{IV} - b^{IV}$ Four Times Accented.	$c^{V} - b^{V}$ Five Times Accented.	$c^{VI} - b^{VI}$ Six Times Accented.	$c^{VII} - b^{VII}$ Seven Times Accented.	$c^{VIII} - b^{VIII}$ Eight Times Accented.
C	1024	2048	4096	8192	16384	32768
D	1152	2304	4608	9216	18432	36864
E	1280	2560	5120	10240	20480	40960
F	1363·2	2726·4	5452·8	10905·6	21811	43622
G	1536	3072	6144	12288	24576	49152
A	1702·4	3404·8	6809·6	13619·2	27238	54476
B	1920	3840	7680	15360	30720	61440
C_{IX}						65536

That these figures may have meaning given them, the following facts may be noted :—

Throughout the sub-contra octave the perception of sound is not very definite, and when heard at all the sounds are heard as a low buzzing or humming. This octave is not used in music except in combination, and it is represented only in the largest organs. Most pianos begin at A_{ii} of the sub-contra octave = 266. vibrations, and extend through seven octaves to c^{v} = 4096 vibrations. The human voice, as used in singing, ranges from the lowest bass notes C of the great octave = 64 vibrations per second, to c^{iv} of the ¼ foot octave, = 2048 (soprano). Madame Nilsson is said to reach 2726 in *Il Flauto Magico*. Individual voices have seldom a range of more than two and a half octaves. Politzer states that the vibration number of his acoumeter is c^{ii} = 512. That of the tick of watches varies, but is generally higher than that of the acoumeter. Notes higher than 5,000 vibrations are hardly ever used in music; the highest notes of the piccolo flute reach this pitch. Above this, the human ear has some experience of notes produced by mice, crickets, etc., but whilst appreciation or hearing of high notes extends up to twenty, thirty, or even forty thousand vibrations per second, the power to differentiate small differences of pitch becomes very faulty after 5,000 vibrations (e^{v}).

Bezold's Continuous Tone Series (*Figs.* 24, 25). — Several attempts have been made to supply a continuous tone-series which would be useful in testing human hearing throughout the whole gamut of appreciable sound. Appun constructed a series of thirty-one forks, the pitches of which ranged from c^{iv}, = 2,048 vibrations, to e^{viii}, = 40,960 vibrations per second. Herr Appun states that the mere work of making these forks cost more than one hundred guineas. Professor Preyer made exhaustive experiments with these forks, and these experiments, together with the parallel experiments with pipes conducted by the writer, have been noticed at length elsewhere.

For clinical purposes the most convenient series of tests is

Fig. 24.—The larger Forks of Bezold's Continuous Tone Series.
The rubber tubes at the sides of the picture are used for blowing the whistles in *Fig.* 25.

Fig. 25.—The smaller Forks and the larger and smaller Whistles of the Continuous Tone Series.

The strikers at the sides of the pictures are used to set the forks vibrating. The clamped forks are struck by the rubber-protected end of the striker placed next them. The striker for the unclamped forks has a metal end.

Bezold's continuous tone series, made by Professor Edelmann, Munich. This series consists of fourteen forks, and two whistles or closed organ pipes with movable stoppers, together with a modified Galton's whistle for the highest pitches. The forks are arranged in two sets of five and nine forks. The five larger forks are struck by the lower part of the palm of the left hand; a striker is used for the nine smaller forks. The forks are provided with movable clamps by which their pitch can be varied. The forks range from C_{ii} = 16 vibrations to c^{v} = 4,096 vibrations per second. The larger of the two whistles or organ pipes ranges from e^{ii} = 640 to a^{iii} = 1,702 vibrations; the smaller from a^{iii} = 1,702 to a^{iv} = 3,404 vibrations per second. The Edelmann-Galton whistle begins at a^{iv} and reaches to a^{viii}, 54,476 vibrations per second. Except that the largest forks are very heavy, and therefore difficult to handle—the largest weighs over 5 lbs.—testing with the series is easy. Bone conduction experiments with the larger forks are valueless, for the vibratory disturbance is too great.

The following are the vibration numbers of the fourteen forks:—

The vibration numbers of the lower forks are taken from the forks themselves.

1	...	C_2 — G_2	... 16 — 24 vibrations	...
2	...	G_2 — D_1	... 24 — 36	.. unloaded 64 vibrations
3	...	D_1 — A_1	.. 35 — 55	.. unloaded 96 vibrations
4	...	A_1 — F	.. 55 — 90	.. unloaded 128 vibrations
5	...	G — d	.. 90 — 150	.. unloaded 192 vibrations
6	...	d — a	... 150 — 212	.. unloaded 256 vibrations
7	...	a — d^1	... 212 — 288	.. unloaded 384 vibrations
8	...	d^1 — a^1	... 288 — 425	.. unloaded 425 vibrations
9	...	a^1 — d^2	... 425 — 576	.. unloaded 768 vibrations
10	...	d^2 — a^2	... 576 — 851	.. unloaded 1,024 vibrations
11	...	g^3 — 1,536 vibrations		
12	...	c^4 — 2,048 vibrations		
13	...	g^4 — 3,072 vibrations		
14	...	c^v — 4,096 vibrations		

The great pipe ranges from e^{ii} to a^{iii} as above noticed, and marks are placed on the inner tube of the pipe for the notes between these extreme points. The same plan is followed in the smaller pipe, the range of which is from a^{iii} to a^{iv}. In the Edelmann-

Galton whistle the width of the mouth-piece can be varied by turning the lower screw, and the length of pipe by turning the higher. A millimetre measure is marked on the instrument, and a table accompanies each instrument, by the help of which any note sounded can be read off by the examiner. (See *Fig.* 23.)

Tests for the Appreciation of Small Differences of Pitch.—This test is rather a physiological than a clinical one; but as cases occur in which appreciation for pitch is disturbed by the onset of disease, a convenient method of measuring such disturbance may be noticed. In constructing a test for the appreciation of small differences of pitch, the writer has made use of two well-known facts in acoustics: (1) When two notes are sounded together which are nearly but not quite in unison, an unsteady sound characterized by alternate increase and diminution of the volume of the sound is produced. This is the "beating" of the tones, and the number of beats per second is equal to the difference in the vibration number of the two tones. (2) Two open organ pipes of exactly the same pitch can be made to differ in pitch (and beat correspondingly) if a movable top be fixed to one of them. When the pipe is shortened the note is sharpened, when it is lengthened flattening results.

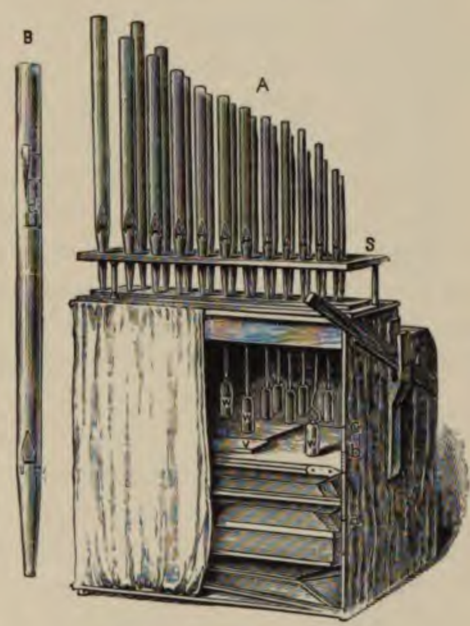


Fig. 26.—Organ Tonometer.

A. Range of pipes
B. Single pipe with moveable top.
V. Constant weight.
W. Secondary weights.
S. Place for siren.

Such is the principle of the *organ tonometer* (*Fig.* 26) of the author. The instrument figured is for the testing throughout two entire octaves of the appreciation of small differences of pitch;

but for use in the consulting-room a smaller instrument of more limited range can easily be made. If two such notes be sounded one after the other, of nearly the same pitch, the opinion of a listener can always be corrected by sounding the notes together and noting the beating of the tones. A difference of half a vibration, or one beat in two seconds, can be accurately measured, the value of this in the fraction of a semi-tone varying, of course, with the position of the notes in the musical scale.

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Tuning-forks used for localization purposes should be fairly large, of moderate pitch, and so loaded that they vibrate as long

as possible (*Fig.* 27). When using the forks aerially, the flat side of the prong of the fork should be held parallel with the side of the head. If the fork be rotated on its axis so that the angle of the prong be nearest the head, "interference" of sound will take place and nothing will be heard. The following fork tests are in common use :—

1. *Schwabach's Test* (Simple Bone-conduction Test).—When there is obstruction in the sound-conducting apparatus (disease of the external or middle ear) a vibrating tuning-fork held against the skull is heard longer than under normal conditions. Schwabach also noticed that the period of perception is shortened in disease of the auditory nerve.

Fig. 27.
Loaded Fork.

2. *Rinne's Test* (Combined Air and Bone-conduction Test).—A tuning-fork held just outside the opening of the external auditory canal is heard a little longer there than when its stem is held against the normal mastoid process. Air conduction, therefore, is superior to bone conduction in normal individuals. When this is the case Rinne's test may be described as positive, thus : Rinne + left ear.

3. *Weber's Test.*—When a strongly-sounding tuning-fork is held against the forehead, or on the vertex, in the middle line, and when one ear is firmly closed by the tip of the finger, the sound seems enforced or strengthened, and is referred to the closed side. The result of Weber's test may be described as : Weber towards the left or right ear ; or Weber in the worse or better ear.

4. *Gellé's Test.*—When an air-tight nozzle is introduced into the external auditory canal and connected by a short rubber tube with an air-bag, it is possible, by compressing the bag, to influence the air-pressure in the meatus, and through the tympanic membrane, the pressure in the middle ear. If the foot-plate of the stapes be movable, the pressure within the labyrinth will also be raised. A sounding fork held on the mastoid process during the

experiment will be heard less distinctly owing to the increased pressure of air, if such increased pressure can be made to reach the labyrinth.

5. *Gardiner Brown's Test.*—A large vibrating tuning-fork held by the stem in the hand of the surgeon is felt to vibrate about the same length of time as it can be heard when applied to the mastoid process of a normal ear. This test is best applied by removing the fork from the mastoid process of the patient, and pressing its end lightly against the tip of the forefinger of the examiner's left hand.

APPRECIATION OF VARIOUS TESTS.

Gardiner Brown's test is of great practical value in high degrees of auditory nerve deafness, and is very easily applied. Weber's and Rinne's tests are the most valuable in the slighter degrees of deafness. They depend for their value on the fact that when the meatus is occluded, *e.g.*, by the finger or by a plug of wax, or when disease interferes with the mobility of the tympanic structures as, *e.g.*, in chronic aural catarrh, the normal inlet for aerial vibrations and the normal outlet for bone conduction vibrations are obstructed. This results in an increase of resonance in the affected ear when the fork tests are employed, and disease of the sound-conducting apparatus is thus made known. Weber's test is chiefly valuable in one-sided deafness. When Rinne's test is negative there is almost certainly disease of the sound-conducting apparatus. A *decidedly shortened* Schwabach means disease of the sound-perceiving apparatus.

The application of these tests will be considered in discussing the diseases for the discovery of which they are applied. But it may be stated that no one test taken alone is of much diagnostic value, and that in some cases, all of them put together will fail to give a safe basis for a diagnosis, unless a clinical history and an objective examination be added. On the other hand, there is hardly any case of deafness which cannot be ultimately accurately diagnosed if the tests are carefully applied, and the results carefully checked and put alongside the clinical history and the objective examination.

The most important aerial test is **Whispered Speech.** If this can be heard distinctly across the length or width of a consulting-room (say 20 feet) deafness of a high degree does not exist. So much cannot be said of any other aerial test. A watch or an acoumeter may be badly heard, and yet hearing for common speech may be good. But for the statements of comparative results, and for noticing the effects of treatment, the watch or the acoumeter is necessary. They give sounds of constant intensity, which whispering does not. Whispering is superior to vocal speech, because the vowels are absent or greatly subdued, and because the test by vocal speech is too loud for the lesser degrees of deafness. When speech in whispers is not heard, conversational tones should be tried, and a note should be made whether the louder vowels alone are heard (*a* and *o*) or the weaker ones also (*e* and *u*).

The same caution must be used in applying the tuning-fork tests. Where only one part of the hearing organ is involved, it is not difficult to localize the cause of the deafness as existing in the sound-conducting or the sound-perceiving apparatus, but it is quite common for one part to be primarily or chiefly affected, and the other secondarily or in a less degree. Further, the results at one part of the scale may not tally with those at the other parts, and thus apparently contradictory statements may emerge at the end of the investigation. But this is not surprising in dealing with an organ with such a wide range as the ear, and the examiner must have beside him (whether he use them often or not) "the whole battery of detective instruments" for the unravelling of difficult cases.

CASE SHEET FOR AURAL PATIENTS.

	Right Ear.	Left Ear.
I. Name, Age, Occupation...		
II. Physiognomy and General Appearance		
a. Mouth breathing		
b. Mastoid swelling..........		
c. Eruptions about auricle ...		
d. Facial paralysis		
e. Glandular enlargement ...		
III. History of Disease.		
a. Suppurative or non-suppurative		
b. Recent or chronic		
c. Family history of deafness		
d. Supposed cause of disease		
IV. Present Symptoms.		
a. Pain.........................		
b. Tinnitus		
c. Giddiness...		
d. Deafness		
V. Mastoid Tenderness?		
VI. Discharge.		
a. Nature and amount		
b. Continuous or intermittent		
c. Is there an odour?.........		
VII. Examination of Upper Air Passages.		
a. Throat.......................		
b. Nose		
c. Naso-pharynx		
VIII. Otoscopic Examination.		
a. External auditory canal...		
b. Membrana tympani		
c. Middle ear		
d. Result of probe examination		
IX. Examination of Eustachian Tube.		
a. Valsalva's method		
b. Politzer's method		
c. Eustachian catheter		
X. Examination by Hearing Tests.		
a. Watch		
b. Whispered speech		
c. Ordinary speech...........		
d. Galton's whistle		
e. Is bone conduction shortened?		
f. Is it better than air conduction?		
g. Is it increased by closing the meatus?............ .		
XI. Does the Deafness vary from time to time?...		
Is hearing better during noise?		
Effect of ventilation of tympanum on the hearing ..		
XII. Remarks		
....		

CHAPTER IV.

GENERAL PROGNOSIS AND TREATMENT.

PROGNOSIS.

PROGNOSIS must be considered with regard to: (1) Hearing; (2) Danger to life.

1. **Hearing.**—Generally speaking, deafness of recent origin is curable, while deafness of very old standing is not. But this general rule is subject to correction by a consideration of the causative agent in each case. For instance, syphilis sometimes causes pretty sudden deafness, which, though treated at once, may never disappear. On the other hand, a ceruminous collection may occur gradually in both ears of a middle-aged or elderly man, and cause, over a period of months or even years, gradually increasing deafness, which can be removed at once by a few applications of the aural syringe. But with exceptions like these the general rule about recent and chronic deafness holds, and it depends for its truth on this fact, that in old-standing ear affections, whether suppurative or non-suppurative, structural changes have taken place in the middle or internal ear, or in both, which cannot be removed even by a removal of their cause. This statement is true, both of chronic aural catarrh and of chronic suppurative otitis media, although the pathological changes in the two diseases differ widely.

On the other hand, in recent diseased processes attended by deafness, the removal of the cause generally cures the deafness. Ulcerative and sclerotic changes have not taken place, and if we except syphilis as mentioned above, and the rapidly destructive changes in the ear attending scarlet fever and diphtheria, and in the auditory nerve in meningitis, the statement that recent deafness is curable is very generally applicable.

Deafness which *varies* from time to time, especially with weather conditions, is generally curable. Such deafness is due to interference with the ventilation of the middle ear by way of the Eustachian tube, and if this air-way can be permanently established, permanently improved hearing will result for the patient.

Hearing better *in a noise* warrants a bad prognosis. This phenomenon (*Paracusis Willisii*) is observed in chronic aural catarrh with thickening and stiffening of structures in the middle ear, also in otosclerosis (*see* page 148).

Heredity, as a factor in the formation of a prognosis, should be constantly remembered. In tuberculosis, in syphilis, in rheumatism and gout, in deaf-mutism, and in many other conditions it has its influence. In middle life, and even in youth, the occurrence of several cases of deafness in a family should warn the practitioner of otosclerosis, and make his prognosis guarded, even if the symptoms in the particular case under notice be in their earliest stages.

2. **Danger to Life** chiefly arises in the course of *suppurative middle-ear disease*, and it is in the chronic rather than in the acute suppurations that septic material is apt to pass into the brain and into the great venous sinuses. The operative treatment for middle-ear suppuration, carried out in the absence of intra-cranial complications, is eminently safe; if the latter be suspected the prognosis must be very guarded. With a single infection—brain abscess or sinus thrombosis—the prospects are better than when there is a mixed infection, and both exist or a meningitis is added. It should be remembered by the surgeon, and carefully explained to the patient, that even in the absence of acute symptoms a middle-ear suppuration is a menace to life; that whilst the danger

may be a distant one, it is pretty sure to declare itself in the long run, unless persistent treatment bring about complete healing.

GENERAL TREATMENT.

The general principles of the treatment of ear disease may be discussed under these headings: (1) The prevention of ear disease; (2) The management of deafness not associated with middle-ear suppuration; (3) The management of suppurative disease within the temporal bone.

1. **The Prevention of Disease.**—Unless there be discharge, cotton-wool should *never be worn* in the external auditory canals. The practice in no way protects the individual, either from ear disease or any other disease. The exceptions which may be reasonably made to this rule are during sea-bathing, and whilst engaged in work amidst very dirty or noisy surroundings; and a specially-made rubber plug (*Figs.* 28 and 29, sound deadeners) is better under these conditions than a piece of cotton-wool.

Fig. 28.—Rubber Ear Protectors

Fig. 29.—Celluloid Ear Protectors.

Pins, hair-pins, and hard instruments should never be used in the ear for the relief of itching, or the removal of cerumen. The ears should be examined and the irritant removed by the syringe.

During the treatment of the *exanthemata* the ears should be examined by the practitioner, whether the nose and throat symptoms are well marked or not; and if the latter are well marked, they should be vigorously treated, in case infection be carried to the ear.

The practice of boxing the ears, either in the family or the schoolroom, should be discouraged. Rupture of the tympanum, or concussion of the labyrinth, may be caused in this way.

People with a family history of deafness must be warned to avoid nasal catarrh, and to attend to the first symptoms of auditory disturbance, whether it be deafness, tinnitus, or other symptoms. Patients who have had middle-ear discharge which has been cured or arrested, must be warned about the readiness with which such discharge returns if re-infection of the middle ear from the throat occur, or if foreign matter (water, soap, dust, etc.) be allowed to enter by the meatus. During sea-bathing, or during the performance of the toilet, the ears of such patients should be temporarily closed by a plug of cotton or by a rubber stopper. Stuffing the corner of the towel into the meatus to dry it, is a practice which often leads to the accumulation of cerumen within the meatus. So also is the use of the instruments called aurilaves, ear sponges, etc. The putting of glycerin, oils, etc., into the ear for the softening of actual or hypothetical plugs of wax, is to be discouraged. The softening action of these agents is almost *nil*. The canal should be examined, and if a ceruminous collection be discovered, it should be removed as directed on page 106.

2. **The Management of Deafness not associated with Ear Discharge.** — The great majority of such cases are due to preceding and long-continued disease of the nose and naso-pharynx. So far as these are causes of aural disease, their management will be discussed in detail in their proper place. Any tendency to cold in the head must be removed, in case it leads to deafness. Nasal obstruction, mouth-breathing, or snoring during sleep, should direct the attention of the practitioner to the examination of the mouth and nose, and their causes should be removed, whether these latter be enlarged tonsils, adenoid vegetations, enlarged turbinated bodies, nasal polypi, a deflected septum, or any other cause.

When deafness actually occurs in these cases, its early treatment is of the greatest importance. After the membrane has been sucked in towards the internal wall of the vacuous drum cavity, after adhesions have taken place between the ossicles and other structures, and after ankylosis of the ossicular joints themselves has occurred, the treatment is even less hopeful than in similar fibroses elsewhere

in the body, for the middle ear is less accessible to massage and other measures for the restoration of function than most other organs. The late removal of the cause of such deafness does not cure the deafness. The indications are for the early removal of the causes, and the vigorous treatment of the deafness at the earliest possible stage.

3. **The Management of Suppurative Disease within the Temporal Bone.**—Once suppuration has begun within the middle ear, all the conditions exist for its prolongation. The middle ear is an ideal incubating chamber, in which the conditions of heat and moisture, so necessary for bacterial propagation, exist. It is surrounded by recesses and smaller chambers, which afford equally favourable conditions, and from which the removal of diseased products is even more difficult than from the middle ear itself. It is true that a tympanic abscess nearly always bursts through the membrane, and finds exit through the smooth-walled external auditory canal, which forms a natural drainage tube from the tympanum. But the exit—the perforation—is often too small; it is often placed wrongly for drainage; and before the latter is thoroughly established, irreparable damage has often been done to the delicate structures in the tympanum, and disease has spread to the important structures around. Hence, a tympanic abscess should be opened at the earliest possible opportunity, and the incision should be made in the best position for drainage. For the same reason, an insufficient opening should be freely enlarged, in a downward or backward direction.

When pus thus finds exit to the external auditory canal, the method of its removal from thence, and from the middle ear itself, must be determined by the surgeon. It may be removed either by the dry method or by an aural syringe. Careful drying by an expert hand will remove most of the secretion from the canal, and theoretically the dry method may lessen the risk of carrying any infection from without. But no drying will remove all the discharge; some must get plastered against the walls of the canal and middle ear, and collect there as flakes of infective material. In all cases,

in the ear of the patient, and in the case of children may greatly frighten them. Syringing should not be continued after the fluid returns clear, and the speculum should be used from time to time, so that the operation be not needlessly prolonged. Except in the case of ceruminous collections and epithelial plugs, prolonged or forcible use of the syringe is never necessary. Ordinary suppurative discharge is removed by one or two fills of the syringe. If giddiness occur, the operation must cease and the head be turned to the side, so that the ear may empty itself quickly, or a cotton tip may be inserted, to soak the fluid from the drum cavity. In any case, very

Fig. 30.—Intra-tympanic Syringe.

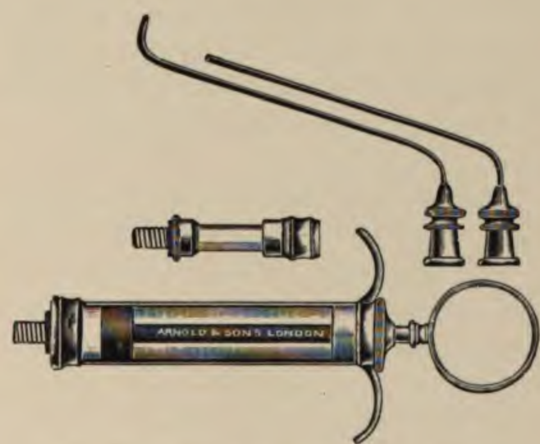

Fig. 31.—Blake's Intra-tympanic Syringe.

careful drying should follow the syringing of an ear. Half a dozen well-applied tips of cotton are necessary for the proper drying of the tympanum and the external auditory canal, and they often have to be applied accurately to small pockets and crevices in the middle ear. The attic and cellar of the tympanum need special care. In disease of the attic, a fine intra-tympanic syringe with a movable tip (*Figs.* 30, 31), capable of directing the current upwards or backwards to recesses containing tough, membranous, or cheesy masses, is necessary. Great patience is required in the

management of such cases, as success may save the patient a serious operation. The treatment must be faithfully carried out by the surgeon.

After the drying of the ear, some special medicament may be applied, according to the indications; but in any case some light dressing must be applied, to prevent the entrance of dust, water, etc. A piece of sterilized cotton or of light tape gauze does well. Such a dressing must be removed before it is soiled to its outer end, and the cleansing of the ear repeated. In addition to their use by the syringe, medicated agents are used in the practice of aural surgery in the forms of the ear bath, ear drops, powders and ointments; whilst stronger agents, such as caustics, are applied on cotton-tips, and probes. Lastly, nasal douches, sprays, and gargles, are used as adjuncts in the management of concomitant diseases of the nose and throat.

Local Sedatives have only a limited use in the treatment of the acute or painful affections of the ear. A poultice should hardly ever be applied to, or near, the ear. If pus exist within the temporal bone, immediate vent should be made for it, and it is better to make an unnecessary incision in the tympanic membrane, than to run the risk of the spread of the suppuration in dangerous directions by temporizing with poultices. After the incision has been made, if pain persist, warm moist heat by fomentation may be tried, or if discharge be profuse, warm antiseptic lotions applied by the aural syringe may be used; but too long time should not be spent over such measures. The persistence of pain means unrelieved tension in most cases, and further operation is demanded.

Local Blood-letting and the application of **Cold** may be useful in the very earliest stages of acute middle-ear affections. The former is best effected by means of leeching, or an incision down to the bone behind the auricle on the mastoid process; the latter by Leiter's coil. Unless the symptoms recede almost at once under these measures, incision of the membrane, and later (if necessary) opening of the mastoid cells must be carried out.

As diagnostic measures, an appreciation has been given of the value of the various methods of ventilating the middle ear: inflation by Valsalva's method, Politzerization, and catheterization. For precision, efficiency, and safety, catheterization stands easily first. The affected ear alone can be separately dealt with, thus eliminating all risk of injury to the membrane of the sound side, and there is less risk of carrying infection into the middle ear from the nose or naso-pharynx than when Politzer's bag is used. Then the width and position of any stricture in the tube can be determined, and its further treatment carried out more thoroughly by dilatation. On the other hand, Politzerization is convenient, more easily applied in the cases of children and nervous patients, and in a few cases, because of the momentary great pressure of air which takes place in the middle ear, it does more for the patient than catheterization. But the catheter cannot be used for children or nervous persons, and many practitioners do not possess the skill necessary for its easy introduction. There is hardly any surgical manœuvre the constant practice of which by the surgeon makes so much for rapidity on his part and comfort on that of his patient. Every patient seems to dread the passage of the catheter. If treatment is to continue, this dexterity must be possessed by the surgeon. For these reasons, therefore, Politzerization is more generally used by the practitioner. And it is after the radical treatment in the nose and naso-pharynx, the removal of enlarged tonsils, of post-nasal adenoids, and of nasal obstructions, that Politzerization has its chief use. Enlarged tonsils and adenoids exist mostly in children, who would not submit to repeated catheterization, and here the air bag alone suffices for the ventilation of the ear, and its use is most important for the further improvement of the hearing. Politzerization should not be started for a week or so after the operation for clearing the naso-pharynx, and during this period the post-nasal space should be made as clean as possible by appropriate treatment.

The use of the **Eustachian Bougie** cannot be said to have passed into the general practice of aural surgery. This is partly because

of the difficulty of using it, and partly because of the temporary and uncertain nature of the results which follow its use. An old stricture in the Eustachian tube, like a similar stricture elsewhere, tends to re-contract, and even if one succeed in keeping it open, the changes in the middle ear which have resulted from the long continuance of such a stricture are usually irremovable. At the same time, cases occur in which it is useful as a part of treatment, and also as a means of diagnosing stricture of the Eustachian tube. Eustachian bougies may be made of celluloid, catgut, silkworm gut, or any substance which has sufficient flexibility and resistance (*Fig.* 32). They must be perfectly smooth on the surface, and must not be brittle, in case the end of the bougie be left in the tube.

Fig. 32.—Eustachian Bougies.

The bougie is passed through a catheter, within which it moves easily. The catheter should be short, but its tip should be long and well curved. It must be held firmly in position during passage of the latter. Upon the length of the bougie is marked the length of the catheter, so that the surgeon may know when the bougie is at the tip of the catheter. The tube is an inch and a half long, and almost all obstructions except bony growths of the osseous part, occur in the cartilaginous part of the tube. About an inch proximal to the first mark on the catheter is placed another mark, for the guidance of the surgeon in estimating the position of the tip of the bougie within the tube. It is seldom necessary to introduce the bougie for a greater distance than one or one-and-a-quarter inches. The middle ear should not be entered. When a stricture is reached, a feeling of resistance is experienced by the surgeon's

hand, and when the stricture is overcome, especially if it be short, the bougie passes onwards somewhat suddenly. The bougie should be passed slowly, with great caution, and if resistance be met with, the instrument should be rotated on its axis as well as pushed steadily forward.

For the removal of the products of inflammation which have caused rigidity of the sound-conducting apparatus, fluids are sometimes injected into the middle ear through the Eustachian catheter. With an intact membrane only a few drops of fluid can be thus introduced. But where perforation has taken place and the perforation is patent, a large quantity of fluid may thus be used, and inspissated material may thus be washed through into the external auditory canal. In either case, whether the quantity to be introduced be large or small, the catheter must be well fitted into the mouth of the Eustachian tube, and the fluid to be injected is driven from a Pravaz syringe, or a larger syringe used solely for this purpose, through the catheter into the middle ear. Some of the fluid passes into the naso-pharynx. With an intact membrane, a few drops of fluid are driven into the catheter by the Pravaz syringe, whence it is further removed into the middle ear by the air-bag applied to the catheter. With a perforated membrane the larger syringe alone is used, and the fluid may be driven through the middle ear.

This method of treatment seems to the writer to have only a very limited use. For the cleansing of the middle ear of inspissated pus, etc., Politzerization, followed by the use of the ordinary aural syringe, or in association with the intra-tympanic syringe, seems sufficient. For the use of this method in chronic aural catarrh *see page* 151.

Massage and Allied Modes of Treatment in Ear Disease.—Both for diagnosis and treatment, it is often desirable to have some means of altering the air pressure within the external auditory canal. If the air pressure within the middle ear has become reduced by closure of the Eustachian tube, inflation from the throat by air-bag alone, or by catheter, may balloon the membrane in whole or in

amongst the deaf, especially in childhood and youth. But in the nose proper, operation is not so likely to be attended by improvement in the hearing. In very old cases of deafness, even if the nasal trouble be the cause of the deafness, the removal of the nasal obstruction is not likely to give back much of the hearing. But in comparatively recent cases, operation on the nose may not only be proper, and directly beneficial to the hearing, but it may be necessary for the easy passage of the Eustachian catheter. If there be subjective nasal sensations—stuffiness of the head, mouth-breathing, and difficulty in getting rid of the nasal mucus—the operation on the nose should be done for the relief of these symptoms, and unless the deafness be very old, the operation should be followed by persistent ventilation of the middle ear, and by catheter, and by other measures for the improvement of the hearing. But operations in old cases of deafness without any subjective symptoms in the nose, will do no good, and their practice is likely to bring aural surgery into disrepute. The surgeon should not accept offhand the statement that the patient has had no nasal obstruction. The latter must be told how to test for such obstruction, and to report to the surgeon the results of his observations. (*See* chapter on "The Naso-pharynx and the Ear.")

For the treatment of nasal conditions causing or accompanying ear disease, local applications may be used, either in spray, vapour, or solution. The most effectual method of applying solutions is by means of the nasal douche (*Fig.* 21, p. 63). The principle of the syphon is made use of here. From a vessel, the bottom of which stands several inches higher than the nose of the patient, the warm solution is made to pass in by one nostril and out by the other, the soft palate (which becomes applied to the roof of the naso-pharynx) directing the current round the posterior border of the nasal septum into the second nostril, and preventing it from going into the pharynx proper. In case the water pressure in the naso-pharynx becomes too great, and the fluid be forced up the Eustachian tube into the ear, the fluid must be made to enter the nose by the narrower, or less open

nostril. The vessel containing the fluid should not at first be more than a few inches above the level of the patient's nose. The solutions used are generally alkaline, so as to detach tough mucus and crusts which may occupy the nose or naso-pharynx.

The Climatic Treatment of ear disease is apt to be overlooked in these days of more efficient local treatment and radical operation. In suppurative disease of the middle-ear, change of air has the same advantage as in suppurative disease elsewhere. The local measures for the stopping of discharge will, if they succeed, be followed by improved general health, and if they fail, change of air will not do much good. Climatic treatment, like tonics and good feeding, must never take the place of well-directed local treatment. But as an aid to the latter, change of air is important.

It is in non-suppurative cases that climatic treatment is more important. Post-nasal adenoids and hypertrophic changes in the nose, causing deafness, are commonest in damp climates, and after these have been corrected by surgical means, removal of the patient to a high, dry climate will do much to restore hearing. But without efficient local treatment to begin with, such removal—unless it be permanent—will not give continued improvement in hearing.

In tubercular cases, prolonged residence at the sea side or, better still, at a high altitude amongst pine woods, may be tried.

CHAPTER V.

DISEASES OF THE EXTERNAL EAR.

Eczema — Herpes — Lupus — Erysipelas — Chilblain and Frost-bite — Lividity—Othæmatoma—Rarer Diseased conditions of the Auricle—Diseases of the External Auditory Canal: Ceruminous Collections, Epithelial Collections, Otomycosis—Foreign bodies in the External Auditory Canal—Boils in the External Auditory Canal—Diffuse Otitis Externa—Cholesteatoma—Stenosis and Closure of the External Auditory Canal—Exostosis of the Canal—Malformation of the External Ear.

THE AURICLE, standing out as it does from the head, consisting of thin plates of cartilage covered immediately by skin, is apt to have its circulation disturbed by changes of temperature, more than any other part of the body. Frost-bite, chilblain, eczema, blood tumour, and injury, are thus predisposed to. Herpes, erysipelas, and other diseases of the skin are also common on the auricle. In addition, the external ear is occasionally malformed. It may also become the site of malignant growth, of abscess, or of cysts, and its cartilage may become inflamed.

DISEASES OF THE AURICLE.

Eczema of the Auricle, except in its causation, and as it is modified by the special anatomical facts above noticed, does not differ materially from the same disease elsewhere. In little children —during the first year of life—the disease is apt to form part of the disturbance attending the eruption of the milk teeth, and attacks the posterior surface of the auricle, the mastoid process, and the groove between these two surfaces, thus having the features of an intertrigo. The disease may be pretty acute, and cause much annoyance to the child. From the third to the tenth year, the disease is very prone to attack the auricle in weakly, strumous

children, and in these cases there is almost always an infective middle-ear discharge, or an infective skin eruption on the side of the head near the auricle. Unless these be discovered, successful treatment is not likely to be instituted. Such an eczema causes crusting of the auricle : the disease may not only spread superficially over the side of the head and face, but may cause enlargement and suppuration of the lymphatic glands near the surfaces involved. It is in tubercular cases, however, that such suppuration of these glands is most apt to occur. In adult life eczema is less common than in childhood ; but a middle-ear discharge, especially if untreated, may set up an eczema of the lobule and neighbouring parts of the auricle, just as it often causes boils in the external auditory canal.

Apart from middle-ear discharge, eczema may be brought about by sudden heating followed by chill, by the excessive heat of the sun, by cold bathing, and during treatment by such drugs as iodoform and boracic acid. In any case of eczema of the auricle, the disease may spread to the external auditory canal. Here, the swelling of the auricle, which is a marked feature of the disease, closes or greatly narrows the lumen of the canal, and if there be discharge from the middle ear, the examination and cleansing of the latter may be a matter of great difficulty. The disease may attack the external auditory canal, without any appearance on the auricle proper. This happens most commonly in adults, and is nearly always associated with some irritant in the canal (cerumen, foreign body, etc.) or with some well-marked constitutional cause (gout, rheumatism). From the canal the disease may spread to the tympanic membrane, causing vesiculation, ulceration, or even perforation of the latter (*Plate III, Fig. H.*).

Acute eczema runs a rapid and definite course. The vesicles rupture, the secretion is abundant, forming when it dries yellowish crusts, and in favourable cases a fine epidermic layer forms underneath these, and recovery takes place. Or, the disease may drift into the chronic form, and then the changes, besides the formation of crusts, are those of thickening of the skin and its underlying

connective tissue. *Chronic eczema* of the external auditory canal causes troublesome irritation, tempting the patient to introduce sharp instruments into the canal and scratch the itching surface. Chronic eczema of the external ear is often very obstinate, and relapses are apt to occur.

The SYMPTOMS of acute eczema are a sensation of burning, tingling, and itching of the auricle. In some cases actual pain is felt, and there may be fever, restlessness, and insomnia. Only if the disease spread inwards to the meatus, is deafness added to the list of symptoms. This deafness is due to the obstruction of the lumen of the canal by desquamated *débris*, and by a swelling of its walls. There may be hyperæmia of the middle ear and troublesome subjective noises as a consequence. In chronic eczema, the chief symptom is the troublesome itching, to which may be added deafness if the canal become occluded by *débris*, and tinnitus, either from the presence of this *débris* or from actual spreading of the disease to the tympanic membrane.

The indications for TREATMENT are, the removal of the cause, whether that be local or constitutional, and the application of proper dressings to the eczematous surface. Unless there be profuse discharge or ceruminous collection in the external auditory canal, the aural syringe should not be used. Neither should the auricle be washed or wetted oftener than is necessary. The canal should be carefully cleaned and dried with fine cotton-tips, and after the crusts have been softened, the auricle should be wiped clean with little pieces of lint or with cotton-wool. Crusts may be softened by a starch poultice, by olive-oil dressings, or by vaseline. After the surface has thus been cleansed, the dressing should be immediately applied. If an ointment, this should be spread on lint, and the latter moulded into the concavities of the auricle and over the helix to the posterior surface, passing, if necessary, into the retro-auricular groove and to the mastoid surface. Neither boracic acid nor iodoform should be used in the treatment of eczema of the auricle, as both sometimes actually produce the disease. If the aural syringe must be used, a weak carbolic lotion is suitable. The

best ointments are those of the oxide of zinc and the oleate of bismuth, in acute or subacute cases, and those of tar and mercury in the chronic cases. In acute cases a lotion of lead is useful, after which the surface may be dusted with zinc oxide or starch powder, or the sedative ointments of zinc or bismuth may be used. In very chronic or scaly eczema, the part may have to be treated with salicylic plaster to effect the removal of the scales.

The general health must not be neglected. In strumous children cod-liver oil and the milder preparations of iron are indicated, whilst in all chronic cases occurring in adults, the administration of arsenic is very helpful. Patients with eczema should not be sent to the coast. If a change of air be indicated, Buxton or Harrogate should be tried, and in any case it is better to send the patient inland than to the seaside.

Herpes, either alone or associated with a neuritis of the auricularis or the auriculo-temporal nerve, may attack the auricle and follow the typical course, the appearance of the vesicles being attended by pain, itching, and fever. The local treatment is by evaporative lotions, dusting powders, and protection of the parts by light dressings. The general treatment is by light diet. and the administration of saline aperients. The pain may be so severe as to demand treatment. Phenacetin or antipyrin may be tried, or if necessary an opiate may be given.

Lupus of the auricle is a comparatively rare condition, which does not differ essentially from a similar condition of the side of the face, with which it is often associated. The particular variety of lupus present on the auricle depends on the character of the disease on other parts of the body, and changes from one form to another may take place. The commonest forms of treatment are based on the destruction of the lupoid tissue by caustics, or the excision of the affected parts, and their partial restoration by plastic operation. Recently, Röntgen rays, Finsen's light treatment, and high-frequency currents have been employed with great success, but whether the results are permanent remains to be seen. Whether

the result be permanent or not, the resulting scar is softer and more pliable than after cutting operations.

When **Erysipelas** attacks the face and side of the head, the auricle often becomes involved. When these attacks are repeated, permanent hypertrophy of the skin over the auricle, and of that lining the external auditory canal, takes place, producing an unsightly thickening of the former, and a narrowing of the lumen of the latter. The treatment is the same as that for the disease elsewhere.

Occasionally still, though not so commonly as formerly, the lobule is pierced for the suspension of ear-rings. A **Traumatic Dermatitis,** sometimes spreading to the deeper tissues, and causing abscess of the lobule, may arise round the point of puncture. The treatment is the thorough disinfection of the wound, and a regular dressing until healing takes place.

Chilblain of the auricle is not uncommon, and in colder climates, **Frost Bite.** The margin of the helix is the part most commonly involved. There is tingling, itching, and actual pain, even in the milder cases, and in more severe cases, necrosis of parts of the auricle may occur. In the treatment of these conditions sudden changes of temperature must be avoided, and if ulcers form, sedative or stimulating applications must be applied according to the nature of the case. Permanent scarring and deformity may follow the healing (*Stereogram XLVII*).

Lividity of the auricle seldom comes before the practitioner as a separate condition. It is generally due to the weakened circulation of old people. In one case of the writer's, occurring in a boy twelve years old, the lividity was very well marked, and was present throughout the whole year, but could be made to disappear at any time by covering the ears with light, warm dressings. The boy had also a tendency to coldness of the feet and hands, but this displayed itself only in winter. There was no cardiac disease, and the boy was not mentally deficient.

Othæmatoma, or Blood Tumour of the Auricle. — This tumour, which is almost peculiar to the auricle, may occur either after injury or without injury, and with peculiar

frequency in the insane. It consists of an effusion of blood between the cartilage and the perichondrium. The tumour occupies the front of the auricle, oftenest in its upper part, but sometimes extending almost to the lobule. The colour is purple or bluish red. It is possible that in many of the so-called non-traumatic cases, occurring in old people and in the insane, slight injury may have occurred; but a predisposition must exist, and this in all likelihood is due to degeneration of the blood-vessel walls. Slight injury may thus cause the bleeding, or it may occur without injury. Othæmatoma occurs in most forms of insanity, in mania, in melancholia, in dementia, and in general paralysis. It is commonest in maniacal cases. (*Stereograms XLVIII, XLIX*, and *L.*)

The SYMPTOMS of blood tumour of the auricle are not acute. There is little pain or local tenderness. The swelling continues for a few days or weeks, the contents of the tumour being either purely sanguineous, or mixed with a yellowish fluid. If unevacuated, or if the sac do not burst, the contents gradually solidify by coagulation, and soon shrinking begins to take place, the fluid parts of the contents are absorbed, and the skin and cartilage become adherent by the development of fibrous bands; the surface of the auricle becomes distorted, and the so-called shrivelled or shrunken ear results.

TREATMENT.—If the contents of a blood tumour be not absorbed within a reasonable time, they should, under antiseptic precautions, be drawn off through a hollow needle or aspirator, and compression applied, with a view to prevent the re-filling of the tumour. Or an incision may be made into the tumour, the contents evacuated, and the cavity packed lightly with plain sterilized or iodoform gauze.

Cartilaginous Tumours occur chiefly on its anterior surface, and may be removed with the knife, and the skin—which has been previously dissected up—be stitched over the edge of the cartilage.

Perichondritis of the auricle may be either idiopathic or traumatic. In the idiopathic cases there may be no discoverable cause. Its course is slow, and may result in shrinkage and destruction of the auricle. Abscesses and serous collections forming in the

course of this disease should be opened as in othæmatoma. Under careful after-treatment recovery occurs gradually.

Epithelioma affects the auricle not infrequently. Free excision should be adopted in dealing with this condition; the removal of the entire auricle will not perceptibly damage hearing. When the auricle has thus to be removed, in whole or in part, or when, after injury, it has to be dealt with surgically, the skin round the edges of the wound should be dissected up from the cartilage, and the edge of the latter shortened with scissors, so as to allow it to be included within the skin flaps, which should then be carefully stitched over the cartilage. These cases should be watched for a time, as even after apparently successful removal, the disease may reappear in the auricle, or even on the side of the neck. It is better to remove the whole of the auricle at the first operation, than run any avoidable risk of recurrence (*Stereogram XLIV*).

Epithelioma may also spread to, or may involve, the external auditory canal. If the diagnosis be doubtful, either here or in the auricle, a small portion may be removed for microscopical examination before any treatment is instituted, but if the ulcerative stage of the disease has been reached, the diagnosis is not difficult. The objective appearances are those of epithelioma elsewhere. The operation, when the disease exists within the external auditory canal, is more extensive than when the auricle alone is involved. The latter should be reflected forwards, the whole extent of the disease ascertained, and the incisions arranged so as to reach beyond the disease, even if the soft parts making up the canal be entirely removed. There is no difficulty afterwards in maintaining the patency of the new canal by the help of careful packing; or success can be attained by the wearing of rubber or silver tubes.

The auricle, like other skin surfaces, may become the site of *cysts* and *wens*. These must be opened and dissected out, or if this be impossible, packed and made to granulate from the bottom.

DISEASES OF THE EXTERNAL AUDITORY CANAL.

The commonest affection of the external auditory canal is **Ceruminous Collection.** It is difficult to account for the recurrence of these collections in the external auditory canals of some patients. Many causes have been given. Some of these are: the unusual shape of the canal preventing the natural evacuation of the ear-wax; improper cleansing of the meatus by people who allow soap and water to enter the canal, and then attempt to dry the canal by a twist of the corner of the towel, thus pushing further in any masses of cerumen which lie near its mouth; the following of an occupation which necessitates the entrance of dust, etc., into the canal; the falling together of the walls of the canal, in old age, etc. There is certainly a hyper-secretion of the cerumen in many cases, and this may be due to a chronic hyperæmia in the walls of the canal associated with chronic eczema, with slight suppuration in the middle ear, and with the habit of picking the ear with sharp bodies to relieve itching (*Plate III, Fig. E.*).

The SYMPTOMS produced by these plugs vary. Generally there is *loss of hearing* to an extent quite beyond the knowledge of the patient, and which is only appreciated by him when the removal of the plug restores him to what he thinks a very noisy world. Here the hearing has been lost *gradually*. In other cases, hearing is lost *suddenly*, either because an existing plug has been moved against the membrane, or has been softened by water entering the ear, and become plastered as a thick mud along the walls of the canal or against the tympanic membrane. Actual *pain* from the presence of a plug may exist, but is not common. Oftener the sensation is described as a dull, wooden feeling, or slight general aching in the head. But acute pain is sometimes felt, and then it may be due to a large plug which has inflamed and excoriated the membrane and sides of the canal; or, without producing these local injuries, the plug may cause pain of the neuralgic type, similar to the pains caused by the presence of bad teeth. The writer has never known the plug to cause perforation, although perforation of the tympanic

membrane and the discharge of pus may co-exist with a ceruminous collection in the canal.

Vertigo and *Tinnitus* are often due to a plug of cerumen, and the writer has met several cases in which the ***appreciation for the pitch of musical sounds*** was disturbed by the same cause. An uncomfortable *itching* in the canal is often due to the presence of scales of dry cerumen on the walls of the canal. An eczema may co-exist with this. By means of hearing tests, the evidence of disturbance of the sound-conducting apparatus may be got, but this is hardly worth practising before removal of the ceruminous plug, because other disturbances of the sound-conducting apparatus may exist within the middle ear.

With the speculum the discovery of a plug of cerumen is not difficult. The canal is seen to be partly or wholly blocked by a mass of dark brown, black, or yellowish-brown material, of a consistence varying from that of a thickish paste to a stony hardness. The tip of the speculum may bury itself in the mass. A probe may be gently used to ascertain its consistence, or to differentiate it from a foreign body, and it should not be forgotten that a foreign body long resident in the canal may become covered with cerumen. Not uncommonly, pus and cerumen are mixed, and when the canal is cleared of the resulting mud, an old suppurating lesion is seen to affect the middle ear. But the pus may be due to another cause. A boil may co-exist, and indeed be due to the irritation of the ceruminous plug, and some time may elapse before the state of matters is quite cleared up, especially if the walls of the canal are so swollen as to make a thorough examination difficult.

The PROGNOSIS is good, but it should be remembered that the deafness present in cases of ceruminous collections may be due to a middle-ear affection. The hearing should be tested a day or two after the removal of the plug, before a final opinion is given.

TREATMENT.—If the plug be soft, it should be forthwith removed by the syringe. A little bicarbonate of soda dissolved in the warm water used in this operation, makes the disintegration of

the plug more rapid, and its removal easier. A solution of peroxide of hydrogen may also be used for this purpose.

If the plug appear to be very dry and hard, and especially if the application of the probe have proved it to be so, its removal should be postponed, unless the symptoms are so urgent as to render its immediate removal necessary. For a couple of days the patient may be directed to instil into his ear, morning and night, a warm solution of bicarbonate of soda (10 gr. to the ounce). The union of the alkali and the fat of the cerumen makes a soap of soft consistence, and one or two applications of the syringe dislodge the plug, either in a single mass or in broken pieces. When the water used with the syringe continues to return uncoloured by cerumen, the speculum should be used to ascertain the state of the parts, as it is not wise to continue the injection of a current against an unprotected membrane. It is quite common to produce giddiness during this syringing, and often after the removal of a large, hard plug, evidences of its pressure may be discovered by the surgeon. These are reddenings and excoriations of the surface of the membrane or the sides of the canal. These as a rule require little treatment, the removal of the cause permitting spontaneous healing; but a soft antiseptic packing may be gently pushed into the canal if there is reason to expect a discharge from an abraded surface, or a dry absorbent powder may be insufflated.

No instrument except the syringe should be used for the removal of ceruminous plugs, unless under a good light; and then, only when the syringe has failed. A probe may sometimes quickly detach a tough, flat piece of cerumen plastered against the wall of the canal, and shorten the washing process.

Associated with ceruminous plugs, or arising apart from them, but in all cases due to a chronic inflammation of the wall of the external auditory canal, may exist **Epithelial Plugs.** These are composed of hypertrophied layers of horny cells, and may in time cause deafness, tinnitus, and even pain, by their presence in the canal. The treatment consists of removal by syringe and forceps, after previous softening. Many sittings may be necessary for the

complete removal of these tough masses, and the canal should be regularly inspected for some weeks afterwards, to make sure that there is no tendency to recurrence. Any middle-ear suppuration which exists must be treated to a successful finish.

A condition known as **Otomycosis** sometimes causes symptoms like those due to ceruminous collection or epithelial plugs—deafness, fullness in the ears, itching, tinnitus, and even acute pain. It is due to a fungous growth—the *aspergillus niger* is the commonest variety—in the external auditory canal. Thick flakes of epithelial matter form, infiltrated with serum, and come away with the syringe or by the help of instruments, as whitish masses sprinkled with sooty-looking specks. Under the microscope these latter are seen to consist of characteristic epithelial network and fruit-like spores.

The TREATMENT of otomycosis consists of the removal by syringe, and if necessary by forceps and curette, of all epithelial masses, and the subsequent instillation of antiseptic lotions—carbolic acid or weak sublimate solution—till the soft parts return to the normal.

Foreign Bodies in the External Auditory Canal.—It is in children that these have oftenest to be dealt with. Beads, bits of slate pencil and wood, beans, peas, etc., are often found in the ears of children. In the adult, forgotten pieces of cotton wool are of common occurrence. The latter are easily dealt with by means of the aural forceps or a cotton holder. But smooth, rounded bodies, like beads, are difficult to remove by any forceps, or indeed by any instrument; and soft vegetable substances, like peas, swell, if water be used with the syringe for their extraction. It should not be forgotten that a foreign body may remain in the canal for a long time—many years even—without giving rise to any trouble. When examining a hundred and fifty children at the Deaf and Dumb Institution in Glasgow, the writer found all the above-mentioned substances in the meatus, and none of them was at the time causing any symptoms, nor indeed was their existence known before the examination. But when the presence of a foreign body in the canal is known, the patient or his more nervous parent usually desires its removal.

TREATMENT.—As in the case of the ceruminous plug, the syringe is the best means for the removal of these intruders ; but it should not be forgotten that, as already mentioned, water used with the syringe will swell vegetable substances like peas and beans, and make their removal more difficult. Oil, alcohol, or glycerin, may in these cases be tried with the syringe. In any case, syringing should not be given up without fair and extended trial. If the syringe fail, and if the symptoms are urgent, some kind of pointed extractor may be tried. It is assumed that, even before syringing, the presence of the body has been ascertained through the speculum, with the help of a good light, and of course no foreign body in the canal should be touched at all with a solid instrument, unless under continuous illumination. A pair of forceps, for instance, applied to a bead in the canal, will in nine cases out of ten fail to grasp the bead, and will as certainly drive it further towards the middle ear beyond the waist or isthmus. Meddlesome surgery has been known to drive a foreign body through the membrane.

The writer does not know any solid instrument which can be uniformly applied with success for the extraction of foreign bodies from the external auditory canal, and is in the habit of making one for each case as it comes. A bent probe, a steel crochet pin, or other fine hook, will often succeed when the syringe fails ; but these should not be used so as to cause bleeding, and they, like forceps, too often drive the body further towards the middle ear. The kind of instrument selected will depend on the nature of the foreign body, and its position in the external auditory canal. If the body lie superficial to the isthmus of the canal, the probe or hook is passed along the roof of the canal, and when its tip is well beyond the foreign body, it is used as a lever to expel the latter. But beyond the isthmus of the canal, at the inner end of the osseous meatus, such use of a hard instrument would probably injure the upper part of the membrane, and would also, in all likelihood, drive the foreign body further in. Beyond the isthmus, therefore, the hook will most safely reach the foreign body along the antero-inferior border of the canal.

Should all attempts at removal by such means fail, what is to be done? The situation is not a serious, but it is a difficult one. The writer has no hesitation in saying that, although the chances are in favour of the intruder causing no disturbance for a long time, it should be removed. At any time it *may* begin to give trouble. Cerumen will gather about it; from that or some other cause, irritation may begin in the walls of the canal, and removal will be demanded when swelling and pain have made the conditions for removal much less favourable. Before resorting to operation, there is one method which merits special notice; that is, the agglutinative method. A match or a small camel-hair pencil has its tip steeped in glue or seccotine, and after the canal is thoroughly dried, the tip is applied to the body, the stem cut short, and the tip left *in situ* for twelve or twenty-four hours. Hardening takes place, with firm adhesion between the applied surfaces, and careful traction will thus sometimes remove a foreign body which has resisted other methods.

The writer has only once been compelled to lay forward the auricle and open the cartilaginous canal for the removal of a foreign body, but he thinks the procedure is justifiable if all other methods have failed, and if middle-ear suppuration or urgent symptoms exist. The steps of the operation are the same as in the initial stages of the mastoid operation (*see p.* 209). In addition to the danger already mentioned—that of pushing the foreign body inwards—necrosis of the walls of the external auditory canal has been known to result from clumsy attempts at removal of foreign bodies from the canal.

Insects which have crept into the external auditory canal are most surely dislodged by pouring carbolic oil into the meatus.

Eczema of the external auditory canal has been considered along with eczema of the auricle (*see page* 100). After the removal of *débris* from the canal, remedies may be applied on cotton tents. The ointments of oleate of zinc, or of tar and mercury, should be applied on cotton-tips, and if these be left to act as tents, dilatation of the canal is effected. The treatment of any suppurative condition of the middle ear must be carefully carried out.

Boils in the External Auditory Canal.—These troublesome local swellings often come without any ascertainable cause; on the other hand, they are often secondary to suppurations within the middle ear, and they are often associated with ceruminous collections in the external auditory canal. These latter, by setting up itching, tempt the patient to relieve himself by putting hair-pins and other sharp bodies into the ears. An infective inflammation is thus set up, and a boil results. When boils in the canal occur in crops or in a series, a constitutional cause such as diabetes should be looked for; but the isolated boil of irritation is not so associated.

When a boil occurs in the external auditory canal, the close relation of the skin and the cartilage modify the nature of the symptoms. There is no room for great swelling; the parts become very tense, pain is great, not only in the ear but over the whole side of the head and neck. Any movement of the auricle increases the pain, and sleep may be much disturbed. The lumen of the canal is narrowed, and any attempt to clear *débris* from its deeper end is rendered very difficult. More than one boil may be present, and complete occlusion of the canal may occur. There may be tumefaction of the mastoid process or surrounding parts, but periotic glandular swellings are not common in furunculosis.

In one situation the diagnosis is not always easy—on the postero-superior wall of the canal. Here a nipple-like swelling like that of a boil may be due to a mastoid fistula opening from the border cells into the bony canal. If the probe be used the diagnosis will be cleared up, for in the case of the bony fistula the tip of the instrument strikes the bared bone. Further, the history of a long-standing disease of the middle ear, followed by a swelling of the canal in the situation above described, will at once rouse the suspicion of the surgeon as to the presence of something more than a boil.

TREATMENT.—The first indication is the clearing of all *débris* from the canal by a warm antiseptic lotion; the second, the free incision of the swelling. A bicarbonate of soda lotion disintegrates the *débris* if it resist the action of the antiseptic solution. Free

incision is attended by immediate relief, and further relief and subsidence of the swelling will be obtained by the often repeated use of hot carbolic or boracic lotion, and by the use of warm fomentations to the side of the head. The after treatment of this condition is the scrupulous cleansing of the canal; and the oversight of it by the surgeon till all likelihood of recurrence is past, is of the greatest importance. The microbic origin of the disease, and the value of antiseptic treatment, must not be forgotten.

Diffuse Inflammation of the external auditory canal may occur in connection with middle-ear suppuration, with the presence of ceruminous plugs or foreign bodies, or with attempts to remove the latter. It may develop from a boil or other local inflammation. The conditions present are similar to those in the circumscribed form, but the skin surface involved is larger, and the surrounding soft parts about the auricle are more largely involved. Spreading to the tympanic membrane and through it to the middle ear is more common. Chronic discharge may thus be set up, and the bony walls of the middle ear or the ossicles may become diseased. Stricture of the canal may result.

Diffuse *otitis externa* may be either acute or chronic. In the acute form pain is often very great, especially if the inflammation have extended to the periosteum and bony walls of the canal. If the middle ear be involved there is also tinnitus, and if the lumen of the canal be occluded, or nearly so, there is a good deal of deafness. As disturbance of the anterior wall of the canal is caused by movements of the lower jaw, these movements produce pain. The symptoms in the chronic variety of diffuse otitis externa are less severe, and consist in itching, tinnitus, and if the canal be closed or the middle ear involved, a good deal of deafness.

The DIAGNOSIS is not always easy. Both in the acute and chronic varieties the swelling of the canal is so great that the insertion of even a small speculum is painful or may be impossible. Then, in the chronic cases at least (when both are present), it may be impossible to say whether the otitis externa is due to an antecedent middle-ear inflammation, or *vice versa*. It may be

impossible to obtain a view of the tympanic membrane, or to say at the first examination whether the middle ear is involved or not. The history of the case and a careful otoscopic examination of the canal after all *débris* has been cleared away, will enable the practitioner in most cases to come to a correct diagnosis.

TREATMENT.—This is the same as for furunculosis, except that incision is seldom necessary. All *débris* should be removed by the syringe. The canal should be well dried by fine cotton-tips, then a fine cotton tent smeared with vaselin or other bland ointment should be left in the canal for twelve or twenty-four hours. This produces widening, and subsequent examination and treatment are rendered easy. Weak carbolic lotion makes a good ear-wash in these cases. Boracic acid sometimes irritates, but a solution of boracic acid in spirit (1–20) may be painted over the walls of the canal occasionally, both in furunculosis and in diffuse inflammation, for some weeks after the disappearance of the inflammation. Recurrence is thus less likely to take place.

Caries and Necrosis of the external auditory canal will be more fully treated of under the heading of suppuration within the temporal bone, but there is a small number of cases in which necrosis occurs without disease of the middle ear or mastoid cells.

In one such case in the writer's practice the history pointed to picking the ear with a pin as the cause. The necrosis was on the anterior and lower wall, and an abscess had burst just below the lobule. The middle ear was intact and the hearing perfect; all the tissues towards the mastoid cells were normal. One or two other cases of a similar nature have occurred by the accidental injury of the walls of the canal with such sharp bodies as crochet pins, and several more by the pressure of hard foreign bodies, or clumsy attempts at the removal of these. The treatment of such a condition involves the removal of any foreign body which may be present, the curetting of the bony surface and its surroundings, the opening of all contiguous collections of pus, and the thorough packing of the resulting cavities.

Another condition developing from chronic inflammations of the external auditory canal, is **Cholesteatoma** of the canal. This condition is similar to that already referred to as an epithelial plug (*page* 107). The desquamative processes which are the result of chronic inflammation, may produce closely packed layers of epidermic material which fill the inner end of the canal up to the tympanic membrane, and by their pressure may cause absorption of the walls of the bony canal. Such collections need not produce painful symptoms. For their removal, preliminary softening with a 10-volume solution of peroxide of hydrogen, and syringing with a warm antiseptic lotion, are all that is necessary in most cases. Detachment by probe, and removal of the adherent masses by forceps, may expedite the process. Afterwards the walls of the canal should be regularly painted with boracic acid in alcohol to prevent recurrence.

Polypi may appear in the canal in connection with chronic otitis externa, and may project so as to be visible at the outer end of the auditory canal. As a cause of polypus, however, middle-ear suppuration is much more common (*see Chap*. VIII). If middle-ear suppuration can be excluded, the occurrence of a polypus in the external auditory canal should make the practitioner use the probe, so as to discover any affection of the bony walls of the canal which may have arisen in the course of the chronic inflammation of the soft parts.

Stenosis and Closure of the External Auditory Canal.—Narrowing, or occlusion of the external auditory canal, is most commonly the result of a long-continued suppuration of the middle ear. The prolonged irritation present in these cases causes a hypertrophy not only of the soft tissues, but of the bony walls, and the canal may be so reduced in size as hardly to admit a large probe. Such narrowing is greatest near the inner end of the bony canal, beyond which may exist a considerable cavity—the tympanic cavity—filled with pus or other products of chronic inflammation. Thus may arise a very serious state of affairs, in which the middle ear is filled with putrid pus, which may defy all efforts made for its

proper drainage. Further, although cessation of discharge occur in time, the external auditory canal is so narrow that the ingress of sound-waves is interfered with, and great deafness is the result. In all these cases, of course, the tympanic membrane is destroyed, and sometimes the ossicles have been exfoliated. Now and again, one sees a case in which a cicatricial partition has been thrown across the lumen of the canal, and such a partition may look remarkably like a thickened membrane. But it is generally less deeply situated than the normal membrane, and has a flaccid white look easily distinguished from that of the true membrane. The symptoms which call for treatment in these cases are: (1) deafness; (2) the presence of a discharge the source of which cannot be drained, and which may at any time become a danger to the life of a patient.

TREATMENT.—For membranous partitions of the kind above described, simple slitting or puncture with the galvano-cautery will suffice. It will often be found that beyond the partition there is great narrowing of the bony canal, and to get the required improvement this latter must be widened. To prevent re-formation of the obstruction in the soft parts, a tent of cotton wool must be worn, or a metal tube may be kept in the canal till healing of the walls is completed. For the widening of the bony canal resort must be had to some form of burr or drill. In these cases it is best to reflect the auricle forwards, split or pull outwards the cartilaginous canal, widen the bony canal upwards and backwards to the required degree, and then replace the split soft parts, packing them well against the walls of the widened canal from the entrance of the meatus. The wound on the mastoid surface is closely stitched, and heals at once.

There is another class of cases which must be dealt with on similar lines—that of local **Hypertrophy** or **Exostosis of the Bony Walls** of the external auditory canal (*Plate III., Figs C, D.*). These growths are generally of ivory hardness, and may be multiple. The writer thinks with Pritchard, that these growths are sometimes the expression of the rheumatic tendency, and believes he has seen

their progress arrested by iodide of potassium given internally. They sometimes also occur in syphilitic subjects. Their diagnosis is easy if the probe be used. To the point of this instrument they present a surface of ivory hardness under a thin covering of pale pearly skin. When they are multiple, a mere chink may be left between the opposing masses, and the lumen of the canal may be almost closed to sound-waves. If pus exist beyond the obstruction, they may interfere with its exit, but unlike the cases of general stenosis, these localised bony hypertrophies are not usually associated with suppurative disease of the middle ear.

The writer has watched some of these cases for many years without noticing any alteration. If pain arise from the pressure of opposing surfaces, or if secretion be retained, operation may become necessary. This is best performed by the burr or drill *via* the external auditory canal, and if aseptic precautions be observed, satisfactory healing follows the operation. If the exostosis be not too deeply placed, and especially if it be pedunculated, removal may be effected by means of a few short chips given by a chisel, the edge of which is directed against the neck of the growth. Great care, however, is necessary to prevent slipping of the chisel and injury to the structures of the middle ear. In deeply-placed, sessile exostosis, the auricle should be reflected and the tumour attacked from behind the posterior cartilaginous wall of the external auditory canal by burr or chisel, according as may seem suitable.

A more general **Hyperostosis** of the walls of the canal arises, as has been already indicated, in connection with chronic suppurative middle-ear disease, and forms a serious complication of the latter. It also arises in connection with improper treatment of the post-operation stages of mastoid disease. The writer has seen the wearing of a drainage tube in the canal set up a general thickening of its bony walls, and cause almost complete occlusion of its lumen. The treatment consists of the reflection of the soft parts, of widening the bony parts by chisel or burr, and of packing the soft parts against the widened bony canal.

MALFORMATIONS OF THE EXTERNAL EAR. (*Stereogram XLV.*)

Congenital defect or malformation of the auricle may take the form either of redundancy or overgrowth of the auricle; stunted or deficient development of the auricle; supernumerary auricles, or tubercles near the auricles; or fistulæ or defects in the tissues near the auricle. All of these conditions, except the first, are due to faulty development in the structures forming the first branchial cleft. The external meatus, the tympanic cavity, and the Eustachian tube are formed in this cleft, which remains permanently open, except where it is interrupted by the tympanic membrane. The pinna or auricle is gradually developed on the posterior margin of the cleft. The internal ear is separately developed, but it is not surprising that, with deformity of the auricle and closure of the external auditory canal, the deeper parts in the middle ear and the Eustachian channel to the throat, are also in many cases involved. The position of supernumerary auricles and of branchial fissures and clefts is on the sides of the neck and face. In some cases fissures exist on the neck, which represent the branchial clefts situated behind the first.

Malposition of the auricle, as against faulty development, may take the form either of a too projecting auricle, or of an auricle too closely applied to the side of the head. The former condition is congenital, the latter may be due to the wearing of too closely fitting head gear, such as bonnets in women.

The TREATMENT of malposition or malformation of the auricle may have to be undertaken, either for æsthetic purposes or for the improvement of hearing. An ugly, projecting auricle may have its position improved by the dissection of a skin flap from the mastoid and recto-auricular neighbourhood, and the accurate suturing of the skin edges thus left. A flattened auricle may be improved by altering the style of the head gear so that no pressure is exercised on the auricle.

Malformation due to faulty development may be so annoying to the patient as to warrant the fitting of an artificial auricle (similar

in appearance to the normal ear) to the stump-like malformed auricle.

Such malformation is often associated with ***absence of the external auditory canal***, and the question of operation for the improvement of hearing may be raised by the patient. If the other ear be sound, such operation should be discouraged. The keeping open of an artificially made external auditory canal is a matter of great difficulty, and when it is remembered that the parts in the middle ear are often also malformed or wanting, encouragement to operation is not great. Fortunately such malformation is almost always unilateral, as in the case represented in *Stereogram XLV*. Should the condition be bilateral, or should the other ear be deaf, an operation would be warranted for the establishment of aerial hearing in the malformed ear.

As a preliminary to any such operation, the condition of the internal ear on the malformed side should be ascertained by a series of bone-conduction tests applied throughout the entire range of hearing. Precautions should be taken to exclude as far as possible appreciation by the other ear. In the case represented in *Stereogram XLV*, hearing is present throughout the whole scale, but as the other ear is perfect and its hearing power normal, operation was not advised.

In cases of *supernumerary auricles*, the projections may be removed, and the skin edges stitched, with great advantage to the appearance of the patient.

CHAPTER VI.

THE NASO-PHARYNX AND THE EAR

Relationships of the Naso-Pharynx and the Ear—The Naso-Pharynx—Nasal Affections: Acute Rhinitis—Chronic Hypertrophic Rhinitis—Chronic Atrophic Rhinitis—Deformities of the Nasal Septum—Nasal Polypi and Obstructions—Treatment of the foregoing Conditions—Adenoids—Enlarged Tonsils—Affections of the Eustachian Tube.

THE EUSTACHIAN TUBE, the lower end of which opens into the naso-pharynx, has been described already (*pp.* 19-20) because it is rather an aural than a pharyngeal or naso-pharyngeal organ; but diseases of the nose and naso-pharynx so often precede and accompany those of the ear, that a short description of the anatomy of these parts is necessary. The otologist may almost neglect laryngology, but he cannot ignore the nose or naso-pharynx. He must indeed be a rhinologist too. If he is to use the Eustachian catheter quickly and painlessly, he must have an accurate knowledge of the shape of the structures which go to form the meatuses of the nose; and if he is to treat aural disease successfully, he must be able to treat by reagents diseased conditions of the lining of the nasal cavities, and to remove surgically obstruction within these cavities.

Embryologically, the middle ear is a branch of the naso-pharynx. Physiologically, the middle ear drains into the naso-pharynx, and is ventilated from the naso-pharynx by the Eustachian tube. Pathologically, the naso-pharynx and the middle ear are closely associated. Most diseased processes affecting the middle ear, whether suppurative or non-suppurative, are associated with and preceded by, diseased processes in the naso-pharynx. The latter indeed cause the disease of the middle ear. So that any consideration

of the affections of the middle ear is better taken up after the diseases of the naso-pharynx and Eustachian tubes have been considered.

THE NASO-PHARYNX.

If the nasal septum and the turbinated bodies be removed, the cavity of the nose resembles a pyramid, the apex of which is directed upwards towards the base of the skull in the median line between the orbits, and the base of which is formed by the hard and soft palates. The shape of the pyramid is irregular, its length at the base being much greater than its breadth, though the latter extends to about an inch. The septum of the nose divides this cavity into two pretty equally, except when it deviates from the middle line, and in adult life such deviation is the rule rather than the exception. The septum is made up of the triangular cartilage in front, and of the vertical plates of the ethmoid bone and of the vomer behind (*Stereogram LIV*). Anteriorly, the nose opens on the face by the anterior nares; posteriorly, into the pharynx by the wider posterior nares (*Stereogram LIV*).

The external walls of the nasal cavities are entirely bony, but their surface is much broken up, and the cavities themselves much encroached upon by the turbinated bodies, which project outwards towards the septum (*Stereogram LII*). Under each of the three turbinated bodies is a passage or meatus. All the meatuses open downwards and backwards into the naso-pharynx, but the inferior and middle meatuses open also forwards, towards the anterior nares (*Stereogram LII*). Into the nasal cavities open also foramina from the sinuses round about. The frontal sinus opens by the infundibulum into the middle meatus of the nose; the antrum of Highmore or maxillary sinus opens also into the middle meatus; the anterior ethmoidal cells open, some of them into the hiatus semilunaris and thus into the middle meatus, and some of them directly into the middle meatus, whilst the posterior ethmoidal cells open into the superior meatus. The sphenoidal sinuses open into the posterior part of the superior meatus of the nose (*Stereograms LI, LII, LIII, LIV*).

The mucous membrane covering the inside of the nose is continuous with that lining the various sinuses and cells above referred to—that of the sphenoid and ethmoid cells, that of the antrum of Highmore, and that of the frontal sinus. It is also continuous backwards with that lining the pharynx. Over the septum it is thin, and closely applied to the bone and cartilage. Over the upper part of the septum and the upper parts of the outer walls of the nose, the mucous membrane has distributed to it the branches of the olfactory nerve, and this is the seat of the sense of smell.

The lower parts of the nose—the middle and inferior meatuses—are respiratory in function, and here the mucous membrane differs essentially from that in the higher parts of the nose. It is thicker and more vascular. This is due to large venous spaces in the submucous layer of the middle and inferior turbinated regions. These veins dilate, and the turbinated bodies may swell so as to occlude the meatuses. At other times the bodies so shrink, either spontaneously or under the influence of a drug, as to leave wide air-ways towards the pharynx. The mucous membrane here may become permanently hypertrophied, project beyond the bone, and seem pale and almost pendulous, like a polypus. Varying conditions of the atmosphere, especially as regards moisture and temperature, alter the size of the middle and inferior turbinated bodies, and thus also the patency of the middle and inferior meatuses.

The presence of the turbinated bodies, covered by mucous membrane, greatly increases the surface over which inspired air must pass on its way to the lung, and the shape thus given to the nasal passages by these bodies delays the air within the nasal passages without impeding its progress. The nose thus becomes a warming and filtering organ for the air on its way to the lung. On the other hand, the presence round about the nose of so many accessory sinuses, all opening into it, greatly increases the risk of suppurations of the nose infecting these sinuses, and thus of complicating recovery from suppurative conditions of the nasal mucous membrane.

Further, obstructive conditions of the nose, whether due to deviation of the septum, to hypertrophy of the turbinated bodies, or (as is often the case) to a combination of these, interfere with the ventilation of the naso-pharynx and the middle ear, and thus become a common cause of ear disease. The back of the nose is no longer swept clear of mucus by the passing air current, the naso-pharynx and the mouths of the Eustachian tubes become clogged with mucus, the surrounding muscles become more or less functionless, and catarrhal affections spread readily up the tubes into the middle ear. When nasal breathing is thus interrupted, the air is not prepared for the lung by warming and filtering; it must enter the larynx directly by the mouth, and a liability to affections of the air-passages is thus set up. Under these conditions, also, the unventilated naso-pharynx becomes a harbour for pathogenic organisms, which set up infective conditions of the middle ear.

In aural practice, the middle and inferior turbinated bodies, the middle and inferior meatuses, and the nasal septum, require the special attention of the surgeon. It is through the inferior meatus, with its tip travelling along the smooth floor of the nose, that the catheter reaches the Eustachian tube. The commonest obstructions to its course are deflections and spurs of the nasal septum, and enlargement of the inferior turbinated bodies. It is through the middle meatus that inspired air reaches the naso-pharynx, and obstruction here, by deflection of the septum or enlargement of the middle turbinated body, gives rise to mouth-breathing, and interferes with the ventilation of the naso-pharynx, and, through the Eustachian tube, with ventilation of the middle ear (*Stereograms LII, LIII, LIV*).

NASAL AFFECTIONS.

Apart from the presence of enlarged tonsils and post-nasal adenoids on the one hand, and of nasal affections proper on the other, a naso-pharyngeal catarrh does not often cause deafness. When it exists at all, attention should be directed to those conditions in the nose and throat which usually cause it, and any

treatment which is necessary will form part of the treatment of these affections. Post-nasal adenoids so commonly cause deafness, that their diagnosis and management interest the otologist perhaps more than any other practitioner. Hence this disease will be discussed at some length. It is doubtful if purely nasal affections often cause deafness, but they so often spread backwards and involve the naso-pharynx, the Eustachian tubes, and the middle ear, that a short notice of the chief nasal affections is necessary.

These affections are: (1) *Acute rhinitis*; (2) *Chronic hypertrophic rhinitis*; (3) *Chronic atrophic rhinitis*; (4) *Deviations of the nasal septum* from the vertical, and presence of spurs on the septum; (5) *Nasal polypi* and *suppurations* within the accessory cavities of the nose.

1. **Acute Rhinitis.**—In acute rhinitis, acute nasal catarrh, or "cold in the head," the ear symptoms are often well marked. The whole nasal mucous membrane is swollen, and this extends to the pharynx and to the Eustachian tubes, the pharyngeal orifices of which are closed by the swelling. The inflammation spreads up the tube, and probably involves the blood-vessels of the middle ear. In addition to the general symptoms, there is nasal obstruction, fullness and beating in the ears, tinnitus, watery discharge followed by purulent discharge from the nose, and gradual (and in most cases complete) recovery from all, including the aural symptoms. But if these acute attacks happen often, permanent effects are left within the middle ear and in the lumen of the Eustachian tube. In-drawing of the membrane occurs, adhesions between intra-tympanic structures take place, ankylosis of the ossicular joints follows, and a chronic aural catarrh is established. Stricture of the Eustachian tube is a common result in such cases.

2. **Chronic Hypertrophic Rhinitis.**—In chronic hypertrophic rhinitis there is a hypertrophy of the soft tissues of the turbinated bodies, and sometimes of the underlying bone. Nasal obstruction results, and the mucus in the naso-pharynx collects in tough masses, partly because it is not dried off by the passing air current, and partly because a paresis of the underlying muscles follows, and

their normal contractions which make for its removal are in abeyance. Blocking of the orifices of the Eustachian tubes follows, and slowly but surely a chronic aural catarrh becomes established. The thickening of the turbinals may be uniform from front to back. Masses almost polypoid in shape may form near the anterior end of the inferior turbinal, or towards the posterior end of the same body a mulberry or moriform enlargement may occur, almost in contact with the pharyngeal opening of the Eustachian tube.

The DIAGNOSIS of such swellings of the turbinals is not always easy. They simulate polypi. The latter growths, however, are more translucent, grow from a higher point in the nose, are more pendulous, can be moved more freely by a probe, and are not shrivelled by cocaine or suprarenal preparations, like swellings of the turbinated bodies. The swellings of the posterior end of the inferior turbinated bodies can be seen by the posterior rhinoscopic mirror, or felt by the index finger passed behind the palate into the back of the nose.

3. **Chronic Atrophic Rhinitis.**—In chronic atrophic rhinitis, the contrast is striking when comparison is made with the hypertrophic disease. There is no nasal obstruction; indeed, the nasal passages are usually wider than normal. The discharge is not muco-purulent, but consists chiefly of fetid crusts, and the odour of the breath is easily noticed by those near the patient. But the disease involves the naso-pharynx, spreads up the Eustachian tubes, and may give rise to deafness, tinnitus, and all the symptoms of a chronic aural catarrh or otosclerosis. Or the changes in the middle ear may take the suppurative type. In either case ulceration and stricture of the Eustachian tube is a common link in the chain which connects the changes in the throat and ear.

The type of the disease above described is to be distinguished from that which occurs in syphilitic subjects—*syphilitic ozæna*. In the simpler form of the disease, which occurs chiefly in anæmic and scrofulous subjects, and most commonly in women, the bony framework of the nose is not attacked; in the syphilitic variety

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of the disease, the osseous framework is often involved, and falling in of the bridge of the nose takes place.

4. **Deviations and Spurs of the Nasal Septum.** — These conditions often occur in cases of chronic aural catarrh and oto-sclerosis, and in our anxiety to find a cause for the symptoms in these often obscure cases, we are apt to blame the faulty nasal septum. There is little to support the connection thus indicated; indeed, it is not uncommon to find that deafness is greater on the side towards which no spur or deflection projects.

The DIAGNOSIS of septal deformity is easy. The septum is hard to the touch of the probe, and is not influenced by a solution of cocaine or of adrenalin, like an enlarged turbinated body. A badly deflected septum may cause nasal obstruction, and either alone, or along with hypertrophic rhinitis, may give rise to a naso-pharyngeal catarrh, which in its turn may produce ear symptoms; but unless there be nasal obstruction with subjective symptoms, mere deformity of the septum is not likely to give rise to any disease of the ear.

5. **Nasal Polypi and Suppurations** within the accessory cavities of the nose are the result of acute or chronic rhinitis, and, once they are established, may cause a secondary rhinitis, which will resist all treatment till the suppurative conditions have been dealt with radically by surgical measures. Ear symptoms, either of the suppurative or the non-suppurative type, may arise from the nasal obstruction and the septic condition created by these suppurative diseases.

The objective DIAGNOSIS of nasal polypi has already been noticed (*page* 123, "hypertrophic rhinitis"). The objective diagnosis of suppurative processes within the accessory sinuses (antrum of Highmore, ethmoidal, spehnoidal, and frontal sinuses) is much more difficult. As a rule, the probe passed into the nose touches dead bone in its upper part—middle turbinated region. Pus, flowing from the region of the middle turbinated body, from a mass or from between masses of granulation tissue, should direct the probe of the surgeon in the search for necrosed bone. The direction of

the flow of pus should be noted. Pus which tends to flow into the mouth when the patient is erect, probably comes from the sphenoidal sinus or the posterior ethmoid cells. Pus which flows into the anterior part of the nose under similar conditions, is likely to be derived from the anterior ethmoid cells or the frontal sinus; while that which flows into the nose and fills its middle or lower meatus when the head of the patient is laid on its sound side, is most probably derived from the antrum of Highmore. In trying to arrive at a diagnosis as to the source of the pus, ***trans-illumination*** of the face should be called to the aid of the practitioner. When, in a perfectly dark room, a suitably protected electric light is placed in the mouth, and the lips are closed, the sinuses of the face are rendered transparent, a transparency which is interfered with if the sinuses—chiefly the antrum of Highmore—are filled with pus or granulation masses.

The SYMPTOMS which characterize the various nasal conditions which have been briefly described, may be referred to. Except in atrophic rhinitis, there are subjective symptoms of ***nasal obstruction***, viz., a tendency to mouth-breathing, an alteration in the voice, which becomes nasal in character, a feeling of heaviness in the head, chiefly in the frontal region, and a disinclination to mental effort and activity. In acute rhinitis these symptoms soon pass off, but in the chronic conditions they are more or less constant, though subject to improvement when weather becomes clear and dry. It is astonishing how a tolerance becomes established to the chronic discomforts which attend chronic naso-pharyngeal catarrh in most people. These patients only appreciate the amount of the discomfort after the cause has been removed and cure has been effected.

When necrosis of the intra-nasal bony structures, and *accessory sinus suppuration* are added to nasal obstruction, the odour of the discharge becomes an annoyance to the patient, whose sense of smell is in these cases retained. In *chronic atrophic* ***rhinitis***, on the other hand, the sense of smell is destroyed, and although the usual discharge is of bad odour, this latter is not recognized by the patient himself although it makes his presence painfully evident to those about him.

Pendulous masses of the soft turbinated body, whether middle or inferior, are best removed by the cold wire snare, as in the case of nasal polypus. If the outgrowth be of the soft tissue along the whole length of the inferior turbinated body, it is best removed by some form of nasal scissors (*Fig.* 35). The nasal scissors are also best in those cases where it is desirable to remove a part of the bone of the turbinal. It is seldom necessary to remove the whole turbinal bone. Many other instruments have been devised for the removal of these troublesome swellings of the turbinated bodies. The writer prefers the snare and scissors to the spokeshave, etc., because the operator can remove just as much as he pleases, and because there is no risk of tearing away more than is wanted.

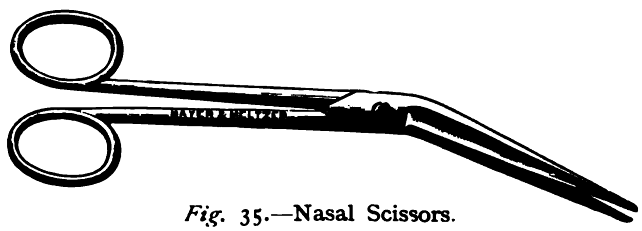

Fig. 35.—Nasal Scissors.

Wounds made thus in the nose heal quickly and well. Before the operation, the parts should be anæsthetized by the application of a 25 per cent solution of hydrochlorate of cocaine, and the bleeding rendered less troublesome by painting the surface with a solution of adrenalin, and after the operation the side of the nose operated upon should be plugged with a piece of gauze tape. If only a small piece have been removed, no packing need be applied, but the surface may be dusted over with aristol, or boracic acid powder. When a packing has been used, it may remain for twenty-four or even forty-eight hours, and the patient must be careful to introduce no dirt or poison into the nose.

Caustics, especially the *galvano-cautery* (*Figs.* 36 *and* 37) have long enjoyed a reputation as a means of reducing the size of hypertrophied turbinals, and there is no doubt that the ultimate result

of the galvano-cautery treatment is good. The method is precise in its application, and the contraction after cicatrization is, as in all burns, very great. But a slough is left in the nose which takes a week to separate; the chance of suppurative complications is much greater than after cutting and snaring operations; and the time of healing is much longer. But the galvano-cautery is a useful means of treatment. It may be employed in two ways. The sharp edge of a burner may be made to cut a long groove along the projecting soft turbinal, or the sharp point may be plunged into the

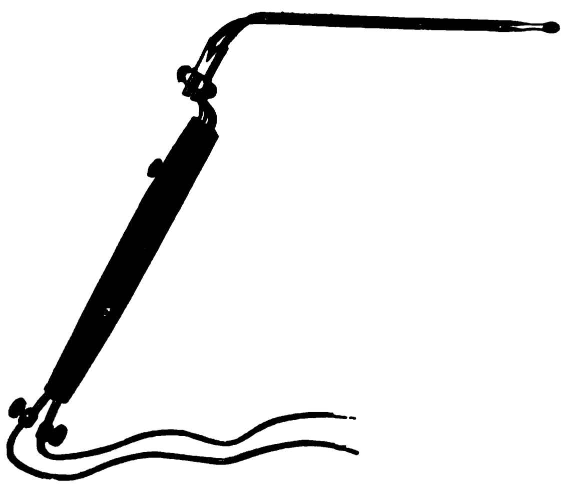

Fig. 36.—Galvano-cautery Burner, and Handle.

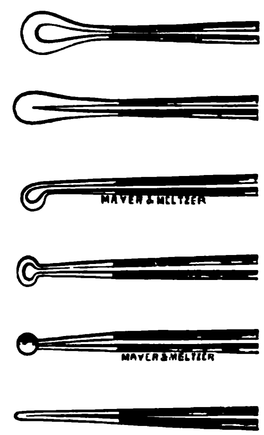

Fig. 37.—Cautery Points.

substance of the soft mass. A minimum of destruction of mucous lining is thus effected, whilst great contraction is got. The destruction of a large mucous area by burning over a large surface is to be avoided if possible. Cautery wounds take three to five weeks to heal, and contraction goes on over a period of many months. It is well not to operate on both sides at once, and not to return to the same side with the cautery without estimating the amount of contraction which will ultimately take place.

The application of *chromic acid* or other *caustic* to the nose

should only be carried out if the better means above described are not available.

Without the above surgical measures the use of nasal douches and other similar applications is not likely to cure a hypertrophic rhinitis; but after or along with such surgical procedures, *alkaline douches* are of great value in completing the cure. The best douches are composed of bicarbonate of soda or borax, and should always be used warm, and of a strength of 10 to 15 grains of the salt to an ounce of water. Residence in a warm, dry climate will greatly assist the cure.

The treatment of **Atrophic Rhinitis** is extremely unsatisfactory. Almost all that can be done is to remove crust by warm alkaline lotions, and to cover the cleansed surface with some oily preparation to prevent the re-formation of the crust on the diseased surface. The fœtor of the breath in these cases can be diminished by adding an antiseptic to the alkaline nasal douche, or by covering the nasal mucous membrane with white precipitate ointment applied by a cotton-tipped probe.

Deflections and Spurs of the nasal septum require removal by operation. It is seldom advisable to use the galvano-cautery here. Unless granulation masses cover the projection or spur—a rather uncommon occurrence—the cautery should not be used. Often a sharp probe-pointed knife can be made to remove all that is necessary from a septal projection, and if at the same time the opposing turbinal be reduced, a good air-way can be established without interfering much with the septum. Should the septum be ossified, and too hard to be cut by a sharp knife, a small nasal saw may be made to cut from above downwards through the bony part of the spur, and the separation of the soft parts below may be completed by forceps and knife. Septal spurs are also thoroughly removed by the electrically-driven burrs.

When the septum is bent, without becoming the site of a definite spur or projection, it may be restored to the vertical or almost vertical position either by forcible straightening, or by a cutting operation which reduces its superficial area, previous to its re-position in the median line.

For forcible straightening of the nasal septum, Adams' forceps may be used, and in order to keep the nasal septum in its new and improved position, some form of nasal splint may have to be worn for a series of weeks. When a cutting operation is required for the purpose of reducing the superficial area of the septum before straightening is effected, the operation devised by Moure of Bordeaux should be adopted.

A Nasal Polypus may be a result of a chronic hypertrophic rhinitis, without any necrosis of the bony walls of the nose, and without any suppuration of the accessory cavities. But the probe should always be used to search for necrosis of bone, and if the latter be found, a more exhaustive search for sinus suppuration should

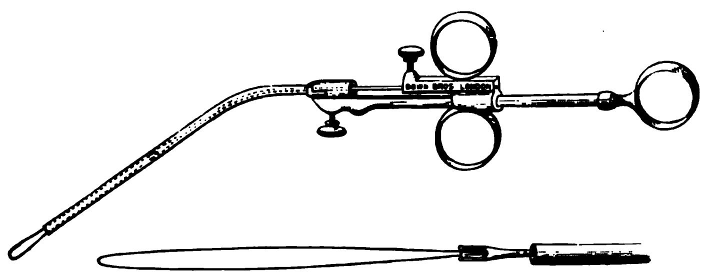

Fig. 38.—Krause's Polypus Snare.

be instituted. When necrosis of bone occurs, it is generally the middle turbinated body which is affected.

Polypi are best removed by cold wire snare, and the underlying necrosed bone, if such exist, should also be removed by snare or forceps. Krause's snare (*Fig.* 38) is the best for the purpose. Several sittings may be required before all the diseased tissue is got rid of. The operative treatment should be followed by the continued use of the nasal douche, till all discharge from the nose ceases. Repeated examination should be made even after apparently complete cure, to make sure that recurrence of the growths has not taken place.

Suppuration within the Accessory Sinuses should be dealt with by radical operation. By the use of the cold wire snare, strong dressing forceps, and curettes, the ethmoidal cells and the sphenoidal sinus may be thoroughly ablated from the anterior nares. Cocaine should be used as a local anæsthetic, but it is better to give a general anæsthetic and to introduce the finger, both by the anterior nares and through the mouth by the posterior nares, so as to get all possible information regarding the parts which need removal. The antrum of Highmore may be opened from the socket of a tooth which has been removed, from the external wall of the nose just below the anterior part of the inferior turbinated body, or through the canine fossa, above the alveolar border and just below the attachment of the upper lip. For exploratory purposes either of the first two methods suffices, but if the antrum is known to contain pus or granulation masses it should be opened from the canine fossa.

This is best done by chisel and hammer, after incising the mucous membrane and periosteum, and reflecting the latter upwards and downwards till a sufficient area of bone is uncovered. The chisel is now applied to the bone above the alveolar ridge, so that the antrum is entered at its lowest part. Widening laterally and in an upward direction is effected either by further application of the chisel, or by the introduction into the wound of cutting forceps such as Jansen's. Or the electrically-driven burr may be used to do this part, or the whole, of the operation on the bone. An opening should be made sufficiently large to permit of the introduction of the tip of the little finger, but in enlarging the opening upwards, care must be taken to avoid the infra-orbital nerve and artery. All granulation masses and pus should be carefully removed from the antrum by suitably shaped curettes, and afterwards an iodoform gauze packing should be made to fill the cavity. Washing and repacking of the cavity should be continued till all trace of purulent discharge has ceased.

Adenoids.—The commonest disease of the naso-pharynx occurs in the young, as post-nasal adenoids. These growths consist of

a hypertrophy of the pharyngeal tonsil, a mass of lymphoid tissue existing in the pharynx near the junction of its roof and posterior wall. This hypertrophy usually commences in the second or third year of life, and persists till the fourteenth or fifteenth, when in most cases atrophy takes place. The growths may be soft and almost pulpy, or hard, tough, almost cartilaginous in character. They seem to be hereditary, and often appear in many or even all the members of a family. They interfere with nasal breathing, cause the inspired air to enter the lung without the proper warming and filtering in the nose, and predispose to bronchial and laryngeal affections. Often, enlargement of the pharyngeal tonsil co-exists with the enlargement of the faucial tonsils. In this case, inspiration is even further obstructed, the chest is never properly expanded, and becomes poorly developed, and the child falls out of health, loses his appetite, and sleeps badly. Snoring is a common result of the obstruction. The nose is necessarily badly ventilated, and mucus tends to gather in it, to trickle from the anterior nares, and to keep up an eczema of the upper lip. Post-nasal adenoids often cause deafness. They block the entrance of the Eustachian tubes, and harbour infective material in the connective tissue which composes them. Deafness is such a common effect of the presence of these growths, that probably the aural surgeon is oftener called upon to deal with them than any other practitioner. Infective material passes from the post-nasal space in these cases, and sets up suppurative middle-ear disease.

CASE I, J. W., *æt.* 10.—*Adenoid vegetations giving rise to recurring suppuration of the middle ear, which latter finally disappeared after removal of the growths.*—During the year preceding May, 1901, three attacks of subacute suppurative otitis media occurred. After the second, the boy was brought to the writer, and, although he advised immediate operation on the naso-pharynx, this was not carried out before the third attack commenced. The tympanic membranes were both intact, but the right was rather redder than normal. After the third attack the operation was performed, and although during July, 1901, the boy took measles when at the coast, there was not then, nor has there been since, any discharge from either ear.

The DIAGNOSIS of adenoid growths is easily made. The child has an open mouth, with a stupid, dull look. (*Stereogram XLVI.*) His speech is nasal and flat, and his facial muscles are inactive, giving the face an expressionless look. When the mouth is opened and the tongue depressed, some of the growths may be seen, but this is not common. Streaks of muco-pus lie on the pharyngeal wall. If the patient be old enough to tolerate the examination, posterior rhinoscopy may be tried, and if successful, the surgeon will see the pale red, finger-like masses hanging down behind the uvula. In younger children, digital examination by the forefinger of the surgeon discovers the masses with ease. Often a firm central mass is felt, but this is not universal. The growths may be well distributed over the whole vault, and in order to produce deafness they need not block the whole air-way. As the finger is withdrawn, some bleeding takes place into the mouth or by the anterior nares, generally the former, and this is of itself of some diagnostic value.

These growths are very common in Britain. Amongst the deaf and dumb children at Glasgow the writer found them in 70 per cent, and in 40 per cent they were well enough marked to warrant removal—interfering as they did with the speech, the breathing, or the general well-being of the child. In respect of the presence of adenoid growths, deaf mutes may be taken as representative of average children. As will be noticed later (*see* "Tubercular Disease of the Ear," *Chap.* VII) adenoid growths harbour the bacillus of tubercle, and in this way almost certainly lead to tuberculosis of the temporal bone. It is almost certain that tuberculosis of the cervical lymphatic glands is caused in the same way.

TREATMENT.—When adenoid growths set up any or all of the symptoms above described, they should be removed. Perhaps no procedure in modern surgery is more satisfactory, safer, and more commonly followed by the desired result, than the operation for post-nasal adenoids when applied to suitable cases. If deafness exist, it is usually removed or greatly improved. General health is improved, breathing and speaking become better. The dull, stupid look of the child gives place to a smart facial expression,

with a closed mouth, and an appearance of attention and intelligence.

Some operators use the finger nail, or an artificial steel nail fixed to the finger tip. The writer is quite sure that many of these masses are too firm for removal by the natural nail, and he knows no advantage of the nail in any case over the instruments used for the purpose. Three short, quick, firm strokes with a Gottstein's ring knife (*Fig.* 39) will clear the naso-pharynx in most cases. The bleeding is profuse for a minute or so, when it suddenly ceases. Some headache lasts for a day or so after the operation ; some blood is swallowed and may disturb the stomach for a day or two. The growths themselves usually slip into the œsophagus and are

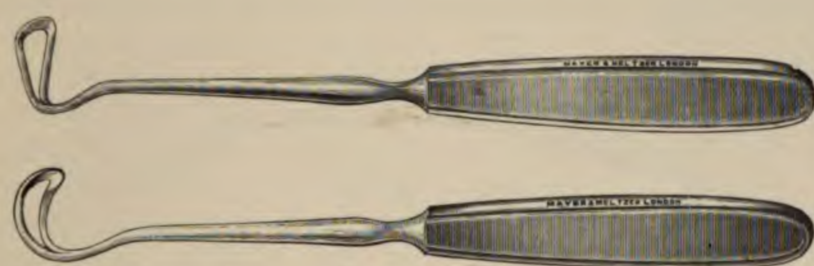

Fig. 39.—Gottstein's Ring Knives.

swallowed, but if the patient be kept indoors for a day or two and a laxative be given on the second day, all disturbance soon passes off. There is no wound in the throat, so swallowing is not much interfered with. No after-treatment need be given for the first few days. Air-bags and nasal douches are better avoided for the first week, in case foreign matter be sent into the middle ear. After a week, if some deafness be left, Politzerization should be carried out for a month or six weeks, and the patient may with advantage be sent to a high, dry, inland health resort.

The operation must not be considered finished till the finger ascertains that the growths have been all removed. If any remain, they should be removed by a fresh introduction of the ring knife. The want of this precaution has given rise to the impression that

"these growths recur." The writer thinks they very seldom recur, and that usually the so-called recurrence is due to want of thoroughness in operating. The nervousness of children, and the need for thoroughness in doing this operation, makes it desirable that an anæsthetic be administered, if it be at all convenient. Ether, chloroform, nitrous oxide, or bromide of ethyl may be used. A smart operator can do the operation well with the shorter anæsthesia, but chloroform is so safe with children that in private practice it is generally preferred. Under anæsthesia, care must be taken that during the rapid bleeding following the strokes of the knife, blood does not get into the larynx. This may be prevented either by having the head hung backwards over the end of a table or sofa, and thus compelling the blood to make its exit by gravitation from the

Fig. 40.—Lœwenberg's Post-Nasal Forceps.

anterior nares, or by operating in the normal position and quickly turning the head to the side on withdrawing the instrument, and letting the blood flow into a flat vessel like a saucer or soap-dish held under the patient's mouth. The anæsthesia need never be deep, as the operation is short. In using the knife it should be remembered that no damage can be done by hard strokes. The knife cannot remove or injure anything it should not touch, for it only catches what projects from the plane of the pharyngeal wall. Many modifications of Gottstein's knife exist, and various forceps are sometimes used (*Fig.* 40). Forceps require repeated introduction, so that unless in adults, or under chloroform, they are unsuitable. Unless the growths yield to the forceps at once, their grip should be loosened in case the vomer be caught. A more lateral grip should then be taken.

Adenoid growths should not be removed during acute inflammatory affections of the throat or ear, or an acute nasal catarrh; but in chronic middle-ear suppuration the operation is not only permissible, but may be the means of causing cessation of the discharge.

Enlarged Tonsils.—Associated with adenoid growths, but belonging to the pharynx, is hypertrophy of the tonsils. It is doubtful if these alone ever cause deafness, but they obstruct breathing, and in cases of deafness, where the adenoids operation is performed, they should be removed also. One of the modifications of the guillotine should be used for their removal. If the tonsil be flat and not easily brought within the fenestra of the guillotine, it may be removed piece-meal by the tonsil punch, or a galvano-cautery point may be plunged into it, and as a result shrivelling will in time take place. Section of the tonsil will display its composition, which may either be soft and friable, composed chiefly of adenoid tissue; tough, from a large admixture of fibrous tissue; or lacunar, with a series of small abscesses or cheesy masses in the substance. The operation of tonsillotomy is nearly always followed by good results, both in the way of improved general health, and in lessening the risk of infection of the cervical glands.

Affections of the Eustachian Tube.—These rarely come before the practitioner as separate clinical conditions. But associated with and causing middle-ear affections, they are of common occurrence. It is in this latter connection that they require careful consideration. The Eustachian tube may be injured by the passage of bougies through the Eustachian catheter, or by the application of electrolysis for the relief of a stricture in its length. Some foreign matter may enter it during vomiting. But it is during the course of affections of the nose and naso-pharynx that the tube becomes diseased. Physiologically, we have seen that its chief function is to ventilate the middle ear, and to regulate the air-pressure in that cavity. Pathologically, its chief rôle is to act as the channel by which disease is conveyed from the naso-pharynx to the drum cavity; these obliterations of its functions as an air-way are followed

by middle-ear disease of a distressing, and often of a permanent type.

Infective material brought by the Eustachian tube to the middle ear, often sets up middle-ear disease of the most destructive type, but these conditions will be studied in detail under the section dealing with middle-ear disease. In the tube itself, the changes are those of an acute or chronic inflammation. In acute nasal catarrh, its pharyngeal orifice becomes occluded by swelling, and adherent mucus or crusts. After a brief, sharp cold in the head, these effects pass off. The symptoms—fullness and blowing noises in the ear, pain on swallowing, etc.—are distressing whilst they last, but if the duration of the nasal inflammation be short, and the recovery from it complete, nothing permanent is left. If, however, the attack be often repeated, or the condition in the nose and naso-pharynx become chronic, the changes in the tube itself and in the middle ear become permanent. Denudation of its lining membrane may be followed by adhesion of the opposite walls of the tube and occlusion of its lumen, whilst chronic inflammation is attended here, as elsewhere, by connective-tissue changes which give rise to permanent stricture of the tube. These changes are most marked in the lower or cartilaginous portion of the tube; in the upper or bony portion, exostoses may cause narrowing, and obstruct the entrance of air to the middle ear. The mouth of the tube may be ulcerated in cases of adenoid growths, in diphtheria, in syphilis, in scarlet fever, or in cancer of the tongue.

The objective evidences of tubal affections are got by posterior rhinoscopy in suitable cases, but chiefly by auscultation with the catheter in position, and by the passage of bougies to ascertain the position and nature of any stricture which may exist.

The TREATMENT consists of removal of the causative condition in the nose and naso-pharynx; of the application of curative agents —douches, sprays, vapours, etc.—by the anterior nares to the naso-pharynx; and of the passage of catheters and bougies for a long time at regular intervals, till any narrowing has been overcome and the normal lumen has been restored.

CHAPTER VII.

DISEASES OF THE MIDDLE EAR.

Classification of Diseases of the Middle Ear, and Importance of Middle-Ear Disease—Inflammations of the Tympanic Membrane: (*a*) Acute Myringitis; (*b*) Chronic Myringitis—Catarrhal Affections of the Middle Ear: (*a*) Acute Catarrh; (*b*) Chronic Aural Catarrh—Otosclerosis—Operations in Chronic Non-Suppurative Middle-Ear Disease—Suppurative Disease of the Middle Ear: (*a*) Acute Suppurative Inflammation; (*b*) Chronic Suppurative Inflammation; Operative Treatment—Artificial Membrana Tympani—Aural Polypi—Tuberculosis within the Temporal Bone—Ear Disease in the Acute Infectious Fevers—Injuries to the Organ of Hearing—Caisson Disease.

CLASSIFICATION OF MIDDLE-EAR DISEASE.

No entirely satisfactory classification of middle-ear affections has yet been made. Bacteriology, which is so rapidly coming to control our ideas about diseased processes, will probably—along with pathology—supply the basis for a final classification. But our knowledge of the pathology of middle-ear affections is far from complete, whilst that of the bacteriology is still in its infancy, so that any classification on this basis must only be provisional, and must be periodically upset as knowledge in these departments of research advances. But there are two broad characters of middle-ear affections, which, if taken along with the accompanying pathological conditions, afford a basis for a provisional classification of great practical use.

1. Middle-ear disease tends either to be *suppurative* or *non-suppurative*.

2. Middle-ear disease tends either to be *acute* or *chronic*.

It is true that acute disease often drifts into chronic conditions, and that what begins as a non-suppurative condition sometimes ends in the formation of pus; but this is often due to the environment of the diseased area rather than to anything essential in the

diseased process itself, and these characters are not peculiar to diseases of the middle ear, but attend the evolution of disease in every part of the body. So that if the provisional classification indicated above be taken as representing broad clinical features rather than rigid pathological conditions, it will be of sufficient practical use.

The importance of middle-ear affections is only properly appreciated, when we consider that most internal-ear affections are secondary to middle-ear diseases, and that the latter may spread not only to the internal ear, but to the surrounding organs, especially to the intracranial structures. It is the mucous lining of the middle ear which, in almost all cases, is primarily affected. There is nothing essentially different in the catarrhal or inflammatory processes which take place within the tympanum, from the same processes going on in any other mucous membrane. But there is a very special character attaching to the theatre in which these processes are carried on. The middle ear is a *very small* cavity, occupied by *mobile structures*, and its function is more or less affected by every catarrhal or suppurative process which takes place within it. Catarrhal affections, if they continue long, result in the formation of connective tissue bands, adhesion of contiguous structures, and loss of mobility; suppurative processes, if they are at all severe, or of long duration, result in loss of tissue—permanent perforation, exfoliation of ossicles, etc.—as well as in loss of mobility in the remaining structures.

DISEASES OF THE TYMPANIC MEMBRANE.

Placed between the external auditory canal and the tympanic cavity, this membrane shares in many of the diseased processes which begin on either side of it, and, semi-transparent as it is, conditions in the middle ear which hardly affect the membrane itself, cause alterations in its appearance easily discovered during examination. Thus, fluid in the drum-cavity may have its level represented by a dark line seen in the membrane, corresponding with the level of the pent-up fluid, or the membrane may be bulged towards the observer by the pressure of fluid from within.

PLATE

III.

What is known as *paracusis Willisii*, or hearing better in a noise, is an almost constant feature of chronic aural catarrh (*see Chap. X.*)

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Otosclerosis.—The above sketch of chronic aural catarrh suggests that the disease is associated with nasal and naso-pharyngeal conditions which cause the ear disease. This is generally the case, and even where the connection cannot be traced at the origin of the ear-trouble, attacks of naso-pharyngeal catarrh increase the tinnitus and deafness in those cases which originate otherwise.

PLATE III.

NON-PERFORATIVE AFFECTIONS OF THE TYMPANIC MEMBRANE.

A.

B.

C.

D.

E.

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G.

H.

I.

J.

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M.

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Acute Inflammation of the Tympanic Membrane. — *Acute Myringitis* (*Plate III*).—This occurs, as a rule, as a result of some affection of the external auditory canal, such as an otitis externa, an eczema of the canal, the pressure of a plug of cerumen or of a foreign body, the entrance of cold water into the canal during sea-bathing, etc. It may also be traumatic, as when a crochet pin is pushed against the membrane. The inflammation is usually confined to the epithelial layers; vesicles may form and rupture, causing excoriations and ulcerations; sometimes the whole thickness of the membrane is involved, and the usual landmarks cannot be made out on examination by the speculum. Rarely does perforation occur; but opaque patches due to calcareous deposit may remain in the substance of the tympanic membrane. When viewed through the speculum, there is reddening of the whole or part of the membrane, the handle of the malleus may be invisible, and only a uniform reddening be seen. Vesicles or excoriations may be discovered, or flaky masses of cast-off epithelium may lie against the membrane or on the walls of the canal. A little serous or sero-sanguineous discharge may be present in the external auditory canal; if mucus be present in the discharge, a perforation should be sought for. The patient complains of pain, fullness in the ear, noises in the head, and, on manipulation of the auricle by the surgeon, pain is increased.

The TREATMENT consists in removal of all irritating matter from the canal, *e.g.*, cerumen, foreign body, pus, epithelium, etc., by warm alkaline lotion applied gently by means of the syringe, the thorough drying of the canal, and the subsequent insufflation of a dry antiseptic powder, such as boracic acid or aristol. The canal should be closed by a light plug of absorbent cotton. It is seldom necessary to put the patient to bed or to resort to local blood-letting.

Chronic Inflammation of the Tympanic Membrane.—*Chronic Myringitis.*—This affection grows out of the corresponding acute condition, if the latter remain untreated; or it may arise without any acute stage from the presence within the external auditory canal

of any irritant, such as a large ceruminous plug, a dirty, infected mass of cotton, or an otitis externa of any sort. The tympanic membrane may be covered by desquamated *débris* mixed with pus, or the surface of the membrane may be covered with granulation masses. The discharge may become caked into crusts, which are difficult to remove, and the condition may simulate a chronic middle-ear suppuration so closely that differential diagnosis is not easy. Careful cleansing of the membrane with a cotton-tip, the use of the probe, the absence of mucus in the discharge, the absence of any evidence of perforation during Politzerization or when the catheter is used, will clear up the diagnosis. The condition tends to recovery if the canal and the membrane be cleansed and kept dry, but permanent thickening of the membrane and calcareous patching may result.

The SYMPTOMS are those of chronic irritation within the canal: itching and discomfort, with but little acute pain. The hearing is less affected than in a middle-ear disease.

The TREATMENT consists in the removal of the irritating materials from the surface of the membrane, and walls of the external auditory canal, and the treatment of any condition—such as boils, eczema, or diffuse inflammation of the external auditory canal—to which the inflammation of the membrane may be secondary. After the canal has been carefully cleansed and dried, boracic acid or aristol may be blown into the canal, and a light cotton plug placed in the outer end of the meatus. The ear should be examined daily, and the dressing repeated as required. Any predisposing cause in the general health of the patient should be treated by tonics and change of air, the seaside however being avoided, if any eczematous element exist in the case.

CATARRHAL INFLAMMATION OF THE MIDDLE EAR.

Following the classification here adopted, catarrh of the middle ear may be *acute*, or it may be *chronic*.

Acute Middle-Ear Catarrh.—The chief predisposing causes of this disease are adenoid vegetations in the naso-pharynx in children,

and nasal diseases in adults. Adenoid growths obstruct the opening of the Eustachian tubes, and harbour pathogenic micro-organisms; nasal obstruction renders the removal of mucus from the nasal cavities and the naso-pharynx difficult or impossible, and the retained discharges supply the micro-organisms which become the immediate cause of the middle-ear affection. The Eustachian tubes become inflamed at the pharyngeal end, obstruction of their lumen occurs, and they thus become a link in the causal chain. The air in the middle ear becomes rarified by absorption, and as obstruction of the tube exists, renewal is difficult. The occurrence of a cold in the head, an exanthematous attack, or an attack of influenza, determines the onset of the acute middle-ear disease. Micro-organisms arrive in the semi-vacuous tympanum. The lining of the tympanum becomes red, swollen, and the cavity more or less filled with a serous exudation in which there are mucus, epithelial cells, some blood corpuscles, and micro-organisms. The changes in the tympanic membrane are limited to the mucous layer for the most part, but in the more severe cases the whole thickness of the membrane may be involved, and then perforation may occur.

If the Eustachian and naso-pharyngeal disturbance be temporary, the attack in the middle ear passes off without leaving permanent changes in the cavity of the latter. If the former be long continued, permanent changes in the middle ear take place. The drum-head becomes retracted, adhesions within the tympanic cavity take place by the formation of connective tissue bands, and a chronic catarrhal condition is established.

If a nasal or a naso-pharyngeal cause be well marked, the SYMPTOMS belonging to these conditions are present, viz., nasal discharge, mouth-breathing, etc. The ear symptoms are a feeling of slight pain of a dull character, or there may be only a sensation of fullness or throbbing in the ear. There is considerable deafness, crackling or bubbling in the ear may be heard, and the patient's voice resonates to him as if he had spoken from the depths of a well—autophony. Through the speculum the membrane is seen

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Otosclerosis.—The above sketch of chronic aural catarrh suggests that the disease is associated with nasal and naso-pharyngeal conditions which cause the ear disease. This is generally the case, and even where the connection cannot be traced at the origin of the ear-trouble, attacks of naso-pharyngeal catarrh increase the tinnitus and deafness in those cases which originate otherwise.

But there are many cases of chronic aural catarrh, or at least of aural disease, with the same symptoms and with but slightly altered objective signs, in which no gross naso-pharyngeal lesion exists, and in which no history of a naso-pharyngeal origin can be discovered.

The pathology of these cases is somewhat obscure. They frequently occur in several members of the same family, and are often associated with the gouty or rheumatic disposition. They also arise in connection with pregnancy, and repeated pregnancies often mean accessions to the amount of deafness and the violence of the tinnitus. But they cannot be described as cases of catarrh in the typical sense. The otoscopic appearances are not well marked. The tympanic membrane and the mucous lining of the middle ear are little altered. The promontory may shine through the membrane and give a pink or rose-coloured appearance to the central zone of the membrane. The immediate cause of the deafness seems to be, in the early stages of the disease, fixation of the foot-plate of the stapes within the oval window. Here, and spreading towards the capsule of the labyrinth, growing bone begins to appear. The new growth takes place in the crura and foot-plate of the stapes, and spreads to the vestibule, the nerve trunks become surrounded by dense connective tissue. The disease has been called *otosclerosis*.

The disease is commonest in the third decade of life, and occurs oftenest in women. Tinnitus is the earliest symptom. This may last for many years before noticeable deafness develops. Giddiness occurs if labyrinthine tension be suddenly increased during the progress of the disease. The Eustachian tube is found to be open. The prognosis as regards hearing is bad.

The term sclerosis has been somewhat loosely applied in connection with chronic middle-ear disease. In conversation recently with an eminent German otologist, the latter asked the writer, when the treatment of these cases came up, "What is sclerosis of the middle ear?" Some writers reserve the term sclerosis for the cases last described, viz., in which the bony changes are conspicuous, and the changes in the tympanic membrane and cavity are hardly demonstrable. Others apply the term sclerosis

immovable within the fenestra ovalis. The bony process of the incus may become fixed against the posterior or upper part of the inner tympanic wall, whilst the handle of the malleus may similarly adhere to the promontory.

With the single exception of the fixation of the foot-plate of the stapes in the foramen ovale, objective evidence of all these changes may be got by examination with mirror and speculum. The membrane itself no longer presents the uniformly curved surface, slightly broken only in its middle by the malleus handle, and above by the short process of the same bone. Its lustre is lessened or has disappeared, and there is either no cone of light at all, or it is broken up or altered in position. The whole central zone of the membrane may be sucked inwards and look thin and bluish, whilst its periphery looks thickened and white, probably because this margin is seen end on (*Plate III, Figs. I. J.*) More commonly this retraction takes place irregularly. Parts of the membrane which have become thinned fall in most, and a puckered, irregular surface presents itself to the observer's eye. One or two features of such cases are fairly common. The handle of the malleus, and the long process of the incus, stand out in greater relief than usual, and the anterior and posterior folds springing from the short process of the malleus, and having Shrapnell's membrane above them, are accentuated. This gives a "fore-shortened" appearance to the handle of the malleus.

During the application of Siegle's speculum, parts of the tympanic membrane may be seen to be too mobile (thin atrophic parts), or the whole membrane may be so tied down that no movement can be produced by suction. If Politzerization be used, the thinned atrophic parts may be ballooned out to resemble blisters. On the other hand, there is generally reduced mobility of the malleus and incus, and though it cannot be demonstrated by direct examination, there is almost always lessened mobility of the stapes within the ring of the oval window. The opinion is generally held that it is this latter fixation—that of the stapes within the oval window—which is responsible for the most distressing symptoms which attend

this disease (tinnitus, etc.). Auscultation during catheterization of the Eustachian tube may discover nothing remarkable, for it is not uncommon for this disease to progress, although the cause in the nose or naso-pharynx has disappeared. The tube may be patent, therefore. But in some cases *râles* can be produced by the air current—mucus in the tube, or exudation within the middle ear; or it may be difficult to get any air-current to pass at all, or a high hissing sound may result; total closure or great narrowing of the Eustachian tube near the isthmus. Such are the objective signs which accompany chronic aural catarrh, one of the most difficult conditions which the practitioner is called upon to treat.

It is probable that paralysis of the tubal muscles plays an important part in the production of some of such cases of chronic aural catarrh. This is most commonly so in facial paralysis and diphtheria, but it may also occur in connection with debilitating conditions, such as overwork, pregnancy and anæmia, etc.

The SYMPTOMS attending chronic aural catarrh are not necessarily conspicuous at the first. Probably the earliest change is diminution in hearing, but as this at first affects only his 'spare' hearing, and as the loss is very gradual, it is for a long time not noticed by the patient. Although the disease is one which generally attacks both ears, it is often much more advanced in one than the other, so that great deafness may exist in the more advanced ear without the fact being known to the patient. Perhaps, in most cases, tinnitus is first complained of, and in many cases it is so prominent and so constant a symptom that it is looked on by the sufferer as more serious than the deafness. The tinnitus is of a high-pitched whistling or hissing kind, is very continuous, and sometimes becomes quite intolerable. If the labyrinth become involved, as it does to a greater or less extent in many of these cases, and if there be any sudden advance in this direction, the patient may experience a sudden collapse attended by great giddiness, vomiting, increased tinnitus aurium, and deafness. All these distressing symptoms gradually pass off, except the deafness, which is usually greater than before the acute attack.

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to the chronic catarrhal cases described in this section. It seems to the present writer better to reserve the term sclerosis or otosclerosis for those cases in which the catarrhal element, as disclosed by the history, and as demonstrated by otoscopic examination, is nearly or entirely absent, and to use the term chronic aural catarrh for those cases which show marked changes in the tympanic membrane and middle ear by otoscopic examination, and which show a history of nasal and naso-pharyngeal symptoms at the beginning of, or during, their course.

The DIAGNOSIS as between otosclerosis and chronic aural catarrh, is not difficult in a typical unmixed case. In otosclerosis, the deafness is progressive, the accessions of deafness are associated with worry, mental strain, or other nervous cause, there is no chronic nasal catarrh or obstruction; but there is often a family history of deafness. Further, there is no marked middle-ear adhesion or retraction of membrane, and the Eustachian tube is normal. Rinne's test is negative, the tones of the deepest forks are audible, but the highest notes are not well heard. In chronic aural catarrh, Weber's test is lateralized towards the diseased or worse ear, Rinne's test is negative, the tones of the deepest forks are inaudible, and there may be absolute prolongation of hearing for the tuning-fork placed on the mastoid process. These hearing tests are not in themselves sufficient to distinguish the conditions from one another; but if hereditary element is absent, if there be a chronic nasal catarrh or obstruction, if the objective signs be those of Eustachian obstruction or stricture, and if there be retraction and adhesions of the structures within the middle ear, the diagnosis is not difficult. It is where the conditions are mixed, or where a labyrinthine affection has been added, that it may be difficult to diagnose the condition, or to give proper value to the elements present.

The TREATMENT of chronic aural catarrh, and of otosclerosis, is the most disappointing part of the work of the aural surgeon. But it is not hopeless, and it should be carried out with determination and great patience. His success will be in inverse ratio to the length of time the symptoms have lasted. The recognition and

thorough treatment of acute and subacute conditions afford his most hopeful field of work. There he will often get brilliant results, and even where he cannot give back full hearing power, he will, in the catarrhal cases at least, generally arrest the further progress of the deafness. That is a good deal to be able to effect in a case which otherwise is certain to get worse.

His attention must be first turned to the *nose and naso-pharynx*. The latter must be emptied of all adenoid growths, and a free air-way must be established through both sides of the former. These measures are demanded for the general well-being of the patient, as well as for the restoration of nasal breathing, which has been lost or greatly diminished; but in all except the most chronic cases they are a necessary introduction to the treatment of the deafness itself. Appropriate nasal douches or sprays should be prescribed if discharge or crusting makes regular cleansing necessary. After this operative treatment has been completed, regular ventilation of the middle ear must be effected, either by Politzer's method, or, better still, by means of the Eustachian catheter. Unless this treatment be almost immediately successful, some form of *massage* of the middle ear should be tried. Suction by Siegle's speculum (*Fig.* 10, p. 52) is simple, and occasionally effective, and during its application the surgeon may watch the amount of reddening the massage produces, and the amount of movement of the ossicles and various parts of the tympanic membrane. Delstanche's rarefacteur (*Fig.* 33, p. 94) acts in the same way, and can be managed by the patient himself. But the best result is obtained by the use of Breitung's pneumo-massage apparatus (*Fig.* 34, p. 95), driven by a motor, either from the main or from a suitable storage battery. The vibrations produced in this way are much more rapid, more regular, and can be uniformly applied over a definite period. Inflation through the catheter should accompany massage, and the treatment may be applied either daily, or two or three times a week, according to the convenience of the patient and the surgeon. In four to six weeks, unless improvement set in, treatment should be interrupted, and the patient sent to a high, dry atmosphere.

Other forms of treatment are by the injection into the middle ear (*via* the Eustachian tube) of the vapours of chloride of ammonium, ether, chloroform, or other vaporous stimulant. Solutions of iodide of potash, of muriate of pilocarpine, of bicarbonate of soda, and of many other salts, are sometimes injected into the middle ear through the Eustachian catheter, with the object of removing, or of producing the absorption of the inflammatory products which cause stiffening of the structures within the tympanum. Liquid vaseline is used in the same way. Unless there be a perforation, only a few drops of any fluid must be used at a time. The fluid, of course, must be warmed and sterilized. The injection is carried out as follows: A Pravaz syringe is filled with the medicated fluid, and its nozzle, which must fit accurately, is inserted into the Eustachian catheter, which has been previously passed into the Eustachian tube. A few drops are now forced into the catheter under slight pressure, and then by means of the air-bag the fluid is forced up the tube into the middle ear. The method is not sufficiently under the control of the operator, who cannot gauge accurately either the amount of fluid which enters the middle ear, nor the force with which it enters. Some of the fluid may escape into the pharynx, and in spite of all precautions, over-reaction and even suppuration of the middle ear may be set up.

The practice of nasal operations with a view to relieving the deafness in these chronic cases, has given rise to what seems to the author an unnecessary amount of difference of opinion amongst aural surgeons. The advent of such local remedies as cocaine and adrenalin has made nasal surgery painless, and almost bloodless; the temptation to operation has therefore increased with the ease of operating. But in most cases of chronic aural catarrh, and in all cases of sclerosis, restoring the air-ways within the nose will *not* restore hearing. The processes within the ear are either finished or are progressing, independently of the nasal condition, so that all that can be hoped for is the prevention of those accessions of deafness which are due to attacks of nasal or naso-pharyngeal catarrh. It is for these latter, and not for the cure of old-standing

deafness, that operation should be undertaken. If, therefore, there are nasal symptoms present, which on their own account warrant operation, the latter should be undertaken; but if no subjective symptoms of obstruction be present, the surgeon is not justified in operating for some slight objective deviation from his idea of the normal.

OPERATIONS IN NON-SUPPURATIVE MIDDLE-EAR DISEASE.
(*The Tympanic Membrane being intact*).

If the treatment of chronic aural catarrh as outlined above should fail, and if deafness be very great, or the tinnitus very distressing, some kind of operative treatment within the middle ear may be thought of. The chief measures of this kind are

1. *Artificial perforation of the tympanic membrane,* with or without removal of a part of the membrane.
2. *Division of the anterior or posterior folds of the tympanic membrane.*
3. *Division of the tendon of the tensor tympani muscle.*
4. *Operations upon the tympanic ossicles.*

None of these procedures is new, and none of them has taken a permanent place in the treatment of this disease. All of them give temporary relief from subjective noises, and sometimes improve hearing. In most cases, however, the relief and the improvement are not permanent. If proper precautions be taken before, during, and after the operation, no bad result will follow; and as the cases for which these operations are proposed are admittedly incurable by other means, a short description of the operations themselves is worth giving.

Unlike the case of chronic middle-ear suppuration in which analogous operations have to be carried out, the field of operation may here be rendered aseptic. On the day before any operation within the tympanum, the external auditory canal should have an ear-bath of peroxide of hydrogen, after which the canal should be washed out with a watery solution of carbolic acid, or of 1–5000 solution of bichloride of mercury in alcohol and water. On the

day of the operation, if fluid be used at all, it should be a sterilized normal salt solution alone. After the cleansing, a plug of sterilized cotton should be worn till the operation begins.

It is better to do without a general anæsthetic. The incision of the tympanic membrane, if it be limited to the membrane, is not very painful, and except in its upper part, is almost bloodless; and after the membrane has been perforated, a twenty per cent solution of hydrochlorate of cocaine introduced within the middle

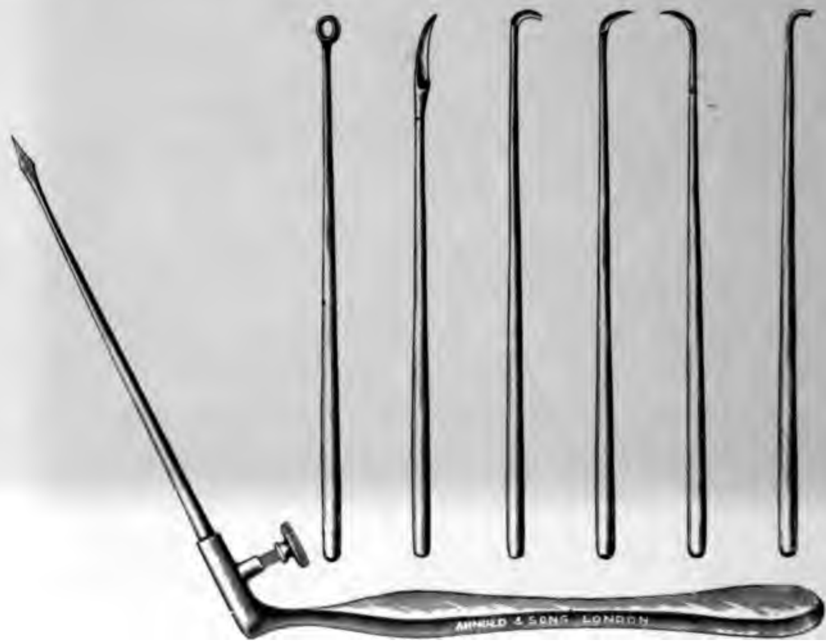

Fig. 41.—Hartmann's Set of Intra-tympanic Instruments.

ear on cotton-tips will control the pain almost entirely, whilst adrenalin chloride, similarly used, will greatly lessen hæmorrhage. Local anæsthesia also has this advantage, that during the course of a prolonged operation, the effects of its various stages on the hearing can be ascertained.

The instruments used must be familiar to the operator, mounted

on delicate stems with straight and bent handles. They consist of sharp and probe-pointed knives, scrapers, probes, hooks, forceps, etc. (*see Fig.* 41). All knives must be very sharp, as this not only contributes to accurate working, but greatly lessens pain in cutting.

1. **Artificial Perforation of the Tympanic Membrane.**—*Myringotomy.*—This is not a difficult operation. The best site for the incision is the posterior section. It should begin in the upper and posterior quadrant, as high up as possible. It is necessary to use a sharp-pointed knife in perforating, but the incision should be continued by introducing a blunt-pointed knife through the perforation, and cutting downward and a little forward in a curve. Unless the deeper parts of the tympanum be injured, there will be little pain or bleeding. If the operation be done for an inflamed condition of the membrane, with the object of evacuating any fluid and of depleting the blood-vessels of the middle ear, it is well to carry the incision, with a sharp-pointed knife, through the mucous membrane of the middle ear, and to make it as free as possible; but if the case be one of chronic aural catarrh, and the object of the incision be exploratory, or introductory to a further operation on the ossicles, the line of the incision should be kept well within the membrane proper, as it is desirable to have the field of operation as bloodless as possible during the later stages of the operation.

Removal of a part of the Tympanic Membrane.—*Myringectomy.*—The incision which has just been described, whilst within the tympanic membrane, is quite close to its posterior border, near its insertion to the tympanic ring. It has been described as being made from above downwards, but it may be made from below upwards. In either case, if the object of the operator is to expose the incudo-stapedial articulation, the upper end of the incision is made to travel across the membrane below the posterior fold to the vicinity of the short process of the malleus, where it turns downwards behind the handle of the malleus, and may be made to run parallel with it as far as the operator wills. A flap of tympanic membrane is thus liberated, attached only at its lower part, and

can be made to fall outwards and display the articulation between the head of the stapes and the long process of the incus. The mobility of the stapes may be tested, and any further operative treatment adopted, or the flap may be folded up again into its original position and supported with a light packing, and in a day or two the wound will be found to have healed. If a permanent opening in the membrane be desired, the flap may be severed at its lower part and removed by forceps.

Even if such a flap as has been described were removed by severing it at the periphery of the membrane, the opening may not be permanent. But the resulting perforation would remain open long enough to enable the surgeon to judge of the effect of a permanent opening through the membrane, or of the probable effect of removal of the whole membrane and of the malleus and incus. The removal of such a flap by cutting is by far the best method of performing a partial myringectomy, but the same result may be attained by a fine galvano-cautery point used against the posterior segment of the membrane, or by a fine cotton-tipped probe which has been lightly soaked in nitric or sulphuric acid. The cutting operation is the most difficult, and is much more difficult than the mere slitting of the membrane, for the detachment of the poorly supported flap is not at all easy, but it gives much the most easily managed wound during the after treatment.

Should the perforation be effected by means of any form of cautery or caustic, suppuration is much more apt to attend the subsequent stages of the case.

2. **Division of the Anterior or Posterior folds of the Tympanic Membrane** may be performed by piercing the membrane with a sharp-pointed knife, and cutting from above downwards till the tight fold gives way. In chronic aural catarrh these two folds form very definite features of the distorted or retracted membrane, and division of them is sometimes performed with the object of restoring, in part at least, the normal position of the structures within the middle ear. The operation has received the name of *plicotomy*, and was suggested by Politzer and Lucae over thirty years ago.

3. **Division of the Tendon of the Tensor Tympani Muscle** was first performed by Weber Liel in 1868. This operation is best performed by the aid of Hartmann's tenotome (*See Fig.* 41) which is introduced through the membrane between the handle of the malleus and the long process of the incus, and withdrawn with its point directed upwards. Another instrument for the purpose is Weber Liel's hook-shaped knife, which is introduced in front of the short process of the malleus. By rotating the handle, the knife is made to embrace the tendon and sever it. Some operators use a blunt-pointed knife curved on the flat. If the operator have a clear idea of the position of the tendon as it approaches the malleus handle from the inner tympanic wall, any of these instruments may be used, and a good deal of latitude may be allowed in the employment of them.

This tenotomy has for its object the relief of a contraction of the muscles, spastic in character, and occurring early in cases of chronic aural catarrh, in the later stages of which the formation of fibrous bands within the tympanic cavity form the most marked pathological change. Did the spastic contraction of the mucles exist as the only diseased condition present, and could such special cases be early and easily recognized, the operation would give good results.

4. **Operations upon the Tympanic Ossicles.**—The operation of partial myringectomy described above, affords the best means of reaching the incudo-stapedial articulation. If by this means the articulation has been displayed, the disarticulation of the incus from the stapes may be effected by an angular knife entered from behind, the incision being carried from above downwards between the two bones (head of the stapes and long process of the incus). Dench advises, as a preliminary step, the cutting of the stapedius tendon. Unless this be first done, there may be difficulty in some cases in inserting the angular knife between the margin of the tympanic ring and the long process. If, however, this preliminary tenotomy be performed, the tensor-tympani muscle, and the fibrous structures in the anterior part of the tympanum,

pull the liberated ossicles forwards, and make the subsequent disarticulation more easily effected. After disarticulation, the ossicles may be sufficiently displaced to permit of mobilization of the stapes. This is best done by a probe or by a finely tipped cotton-holder, which, when applied to the head of the bone, may be made to move the latter from side to side as far as its attachments within the foramen ovale will allow. If fibrosis have fixed the foot-plate within the foramen, the fixing bands may be divided by passing the point of a knife round the foot-plate, and cutting any fibrous bands which bind down the ossicle. If the long process of the incus be so near the margin of the membrane, that the tenotome cannot be introduced between the process and the tympanic ring, the tenotomy may be performed by disarticulating from the front, the angular knife being introduced close behind the malleus handle, and with a downward sweep, made to pass through the articulation.

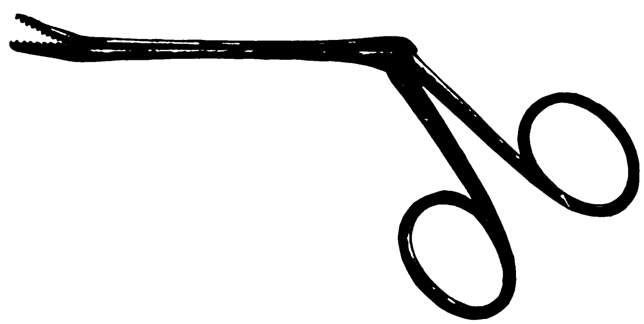

Fig. 42.—Crocodile Forceps.

Removal of the Tympanic Ossicles.—The early stages of the operation for the removal of the malleus and incus, are the same as the steps which have been described for performing the operation of partial myringectomy. After the disarticulation of the incus from the stapes, the crescentic incision—which, starting from the posterior fold of the membrane, reached to the lower part of the membrane—is continued forwards and then upwards, near the tympanic ring, till Shrapnell's membrane is reached. There remain

now for division, the structures connecting the malleus with the tegmen tympani and the tympanic ring—the ligaments of the malleus, the tensor-tympani muscle, and Shrapnell's membrane. These are rapidly divided by a sharp-pointed knife. At this stage bleeding may be so profuse as to obscure the field of operation, but can easily be controlled by pressure of plugs of cotton. The malleus is then seized at the short process—never by the manubrium—by a pair of small crocodile forceps (*Fig.* 42) or by a pair of Sexton's

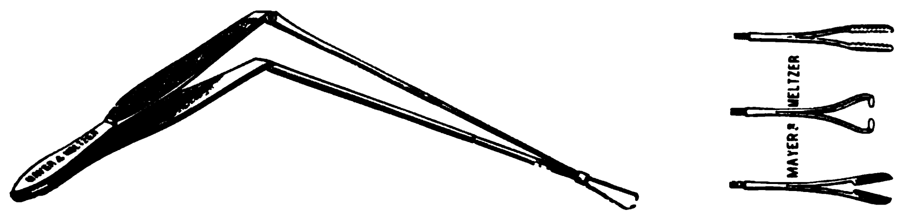

Fig. 43.—Sexton's Ear Forceps.

forceps (*Fig.* 43), and pulled, first well downwards into the middle of the tympanic cavity, and then outwards in the axis of the external auditory canal. After the removal of the malleus, the incus must be similarly seized and removed from the ear, the forceps by choice seizing the ossicle by the long process. Dench emphasizes the difficulty there often is in discovering and removing the incus,

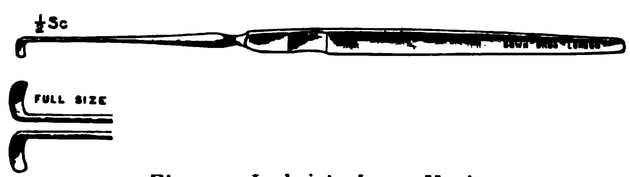

Fig. 44.—Ludwig's Incus Hooks.

which is apt to get almost out of view in the tympanic cavity, in the trough formed just beyond the tympanic ring. An incus hook (*Fig.* 44) is carefully swept round the postero-inferior part of the tympanum, just within the tympanic ring, and if the incus do not appear on repetition of this movement, a similar movement is

conducted in the antero-inferior part of the cavity. These movements, carefully carried out, bring the ossicle into view, and permit of its being removed by the forceps. Care should be taken in thus searching for the loosened incus, not to displace towards it the mastoid antrum (aditus ad antrum). The condition of the stapes may now be ascertained, and its mobility tested, if the ossicle is well within view. If it cannot be seen, Dench punches out the upper and posterior margin of the tympanic ring with a pair of chisel forceps, to bring the ossicle better into view (*Fig.* 48, p. 183).

If it is not intended to remove the stapes, the middle ear is now dried, and a light packing of iodoform gauze left in the external auditory canal. If the stapes is to be removed, it must be freed round its foot-plate from all adhesions, by a sharp-pointed knife carefully used for this purpose. The tendon of the stapedius has been thoroughly severed at an earlier stage of the operation. The head and crura of the ossicle are now seized by a pair of fine forceps, or a hook is passed round the head between the crura, and gentle traction is made till the bone comes away. Care must be taken not to break the crura and leave the foot-plate. Troublesome giddiness is apt to follow the removal of this ossicle.

Operations on the tympanic membrane and ossicles, in chronic non-suppurative ear disease, undertaken with the objects of improving hearing and removing subjective auditory sensations, do not offer an encouraging field for the activity of the surgeon. Artificial perforations of the intact tympanic membrane—unless acute suppurative processes are present—close with certainty, however large they be to begin with, or however carefully kept open. Even when the entire membrane is removed, a cicatricial substitute tends to form, and may have to be repeatedly removed before a patent middle ear remains. Further, the intra-tympanic structures—ossicles, muscles, mucous membrane, etc.—are wrapped about and bound down by cicatricial tissue to each other, or to the membrane, or to both. The field of operation is therefore vicious to begin with, and results which come immediately and seem encouraging, are slowly wiped out by the relentless re-contraction of the incised

structures. Here is Politzer's verdict on the subject : " The operative procedures which were formerly practised to a great extent in the catarrhal adhesive processes and in otosclerosis, did not fulfil the expectations, and the probable results which were at first ascribed to them have dwindled almost to a minimum within the last few years. These operations are : Mobilization of the stapes, synechotomy of the crura of the stapes, excision of the entire membrane, with the malleus and incus, and finally, extraction of the stapes."

On the other hand, Dench seems to think the improvement gained warrants the operation, and indeed makes it incumbent on the surgeon to offer it to the patient. He says, " Of cases where the membrana tympani was intact, including one or two instances where there had been a suppurative process in childhood, ninety have been subjected to operation. Of these there was much improvement in seventy-eight cases; ten were unimproved; one grew worse after the operation ; and in one, the result was unknown." In this statement there is nothing about the permanence or even the duration, of the improvement. After giving further statistics, which have reference also to the result of the operation after suppurative disease, Dench continues, " It will be seen from these statistics that the greatest improvement has followed those operations performed under cocaine anæsthesia, and where the design has been to secure a permanent opening into the tympanum. This seems to be the most rational procedure in all cases where the membrana tympani is intact; and since it can be done without general anæsthesia, we are warranted in recommending at least an exploratory tympanotomy in all cases where the hearing has failed to improve under less radical measures. In no given case can we state the amount of improvement which we should expect, and it is always our duty to inform the patient of the experimental character of the measure. From the fact, however, that the procedure is followed by no discomfort, that it can be performed without pain, and that humanly speaking it will not injure the organ, we certainly fail to fulfil our entire duty to our patients if the subject is not presented to them fairly."

Dilatation of the Eustachian Tube.—Where it can be shown or is strongly suspected that the middle-ear catarrh is due to a stricture of the Eustachian tube, and that such stricture still persists, an attempt should be made to dilate the stricture. This is best done by the gum elastic or celluloid bougies which have been already referred to (*p.* 92). It may also be done by electrolysis, but in either case the stricture is apt to recur after dilatation, and in the application of both methods, but especially of the latter, damage may be done to the tube or the structures surrounding it. Further, the condition of matters within the middle ear is often a finished one, and the symptoms for which dilatation of the tube is undertaken may remain, although the stricture be successfully dilated.

SUPPURATIVE DISEASE OF THE MIDDLE EAR.

When acute inflammation attacks the middle ear, and pus forms, the latter exists under tension. On all sides the abscess is confined by hard, bony walls, except towards the tympanic membrane. Recovery may take place by absorption, leaving the tympanum almost unaltered; or the products of inflammation may form adhesions within the tympanic cavity; if the layers of the membrane have been infiltrated with the exudate, the latter may undergo calcification, and chalky patches may form within the substance of the tympanic membrane; lastly, the abscess may rupture on the side of least resistance—the tympanic membrane—and a perforation may result. Such a perforation may rapidly close, leaving a hardly discernible scar, or, after cessation of the discharge, a dry perforation may persist. A common result is that the discharge persists, and chronic suppuration of the middle ear is established.

Acute Suppurative Otitis Media.—The causes of acute middle-ear suppuration are the infectious diseases, such as scarlet fever, measles, diphtheria, influenza, etc. The micro-organisms which are the immediate cause of the middle-ear disease may reach the middle ear either by way of the Eustachian tube, or directly by the blood stream. Predisposing causes are the presence of post-nasal adenoids, enlarged tonsils, and suppurative conditions in the

nose. Other causes of suppurative middle-ear disease are exposure to cold causing nasal and naso-pharyngeal catarrh and traumatism, acting from the side of the external auditory canal.

The changes within the middle ear during an acute inflammatory attack are, swelling of the mucous membrane, and infiltration of the layers of the drum membrane with the products of inflammation—pus corpuscles and specific micro-organisms, etc. The mucous membrane becomes necrosed in places, and the ossicles and the internal tympanic wall become bared. The bone is also hyperæmic, and if the inflammation is very violent, necrosis of the bone may rapidly result. When the discharge persists, the immediate cause is generally caries or necrosis of the bone, in parts. Probably in acute middle-ear disease, the inflammation is never confined to the tympanum, but extends to the mastoid antrum, the mastoid cells, and even to the capsule of the labyrinth. The symptoms during the stage preceding rupture, and the amount of discharge succeeding rupture of the membrane, are not compatible with the idea that only the small cavity of the tympanum is involved. The inflammation also extends outwards to the walls of the external auditory canal.

The Symptoms attending acute middle-ear suppuration are: Acute pain over the side of the head, pain on pressure over the mastoid process, and on moving the auricle, deafness on the side affected, tinnitus, and giddiness. There is more or less fever, and there may be vomiting, delirium, and convulsions—these latter being commonest in children. There may be swelling of the soft parts, and enlargement of the lymphatic glands about the ear may take place.

The pain is often very acute, is throbbing and sometimes spasmodic in character, and spreads over the whole side of the face. It is made worse by movement of the jaw, and by pressure of the auricle and the surrounding parts. In young children, restlessness, and crying and rolling of the head, or putting the hand to the ear, may be the only expression we have of the presence of such pain; and in the absence of other ascertainable cause, these signs in a young child should always direct the practitioner's attention to the

ear. There is tenderness on pressure of the mastoid process; the mastoid antrum at least, and in many cases the whole of the mastoid cells, being involved in the middle-ear inflammation. The giddiness s due to pressure exerted on the labyrinthine wall through the round and oval windows, and to hyperæmia of the labyrinth and its capsule. The tinnitus is due to the same causes. The temperature may reach 103° or 104° or even higher, especially in children, in whom also the profounder symptoms of general disturbance are, as we have seen, best marked.

On otoscopic examination, characteristic signs are discovered. The walls of the external auditory canal near the membrane may be reddened and swollen; the membrane itself is reddened. In the milder cases this reddening is diffuse and uniform, of a pink or dusky red tint, but there is little or no bulging. If recovery take place without perforation, the reddening lessens, may assume the form of radial streaks, and then disappear (*Plate III, Figs. F, G.*). In more severe cases the reddening is more intense, the swelling of the membrane and the inner end of the canal more decided. Unless resolution now take place, *bulging* of the membrane occurs, most commonly in the postero-superior, or postero-inferior quadrant. Patches of ecchymosis may be seen over the surface. When rupture occurs, the perforation is oftenest in the lower half of the membrane, either in the postero-inferior, or the antero-inferior segment.

With the occurrence of **Perforation**, all the symptoms undergo amelioration. The pain lessens, and if the perforation be not too small for efficient drainage, may suddenly and entirely disappear; the temperature falls, and unless there be extensive mastoid involvement, remains normal. In children, the delirium, vomiting, and other symptoms of general disturbance, disappear. The vertigo and tinnitus improve, and the deafness lessens.

At first the discharge is mixed with blood, but in a short time becomes purulent or muco-purulent. In some cases it lasts but a few days, in many others a week or two. In neglected cases it is apt to be continued as a chronic suppurative otitis media. In nearly

all cases in which proper treatment is carried out, the discharge can be stopped within a month, except where the initial symptoms have been so acute that the bony structures have become rapidly destroyed, as often happens after such diseases as scarlet fever.

When perforation occurs, the diagnosis of its presence and its location is important. It is not easy to see a recent perforation. The tympanum is full of fluid, the perforation is small, and it is much commoner to see a drop of fluid oozing from a slightly distended segment of membrane, than to see the edges of the perforation itself. If the drop be wiped away, it is at once replaced by another. The drop pulsates, or if the perforation be large enough to let one see into the middle ear, the pus there pulsates synchronously with the rhythmical dilatation of the blood-vessels of the tympanum. If the patient practise Valsalva's experiment, a hiss, if the middle ear be nearly empty at the moment, or a series of bubbles if it be full of pus, intimates the fact of perforation to the listener. If mucus be present in the discharge, and there is a perforation, Siegle's speculum may be used to suck the pus out of the middle ear, and demonstrate the fact of perforation. Lastly, the probe may be used, either with its point bare, or covered with cotton. If it pass easily through a suspected part of the membrane, and strike the hard wall of the middle ear, the sensation given to the finger is quite different from that communicated by the intact resilient membrane. These tests, applied singly or in combination, will demonstrate a perforation wherever it exists. A modification of Valsalva's experiment may be tried. The auscultatory (diagnostic) tube should have one end placed in the external auditory canal of the suspected ear, and the other end should be submerged in a glass of water. When auto-inflation or Politzerization is practised, air bubbles rise to the surface of the water. This, which may be called the punctured-tyre method, demonstrates the perforation to all observers, including the patient himself.

The PROGNOSIS in acute middle-ear suppuration is good, if treatment be promptly begun and thoroughly carried through. The worst cases occur in connection with the exanthemata, and

with such diseases as diphtheria and influenza. Here, rapid and extensive destruction of tissue, including the mastoid process, ossicles, and labyrinthine capsule—sometimes occurs. But it remains true that, even including these cases, thorough treatment of acute middle-ear suppuration is generally successful, and if it were always carried out, chronic suppuration would be comparatively rare. When thorough treatment fails to stop discharge in four or six weeks, disease of the bone should be suspected.

Intracranial complications are a very uncommon result of acute middle-ear disease; though a meningitis with metastatic abscesses may follow an acute otitis media (*See* Case 8, *p.* 157). Acute mastoiditis and periostitis are not very uncommon. In tuberculous subjects however the prognosis is bad.

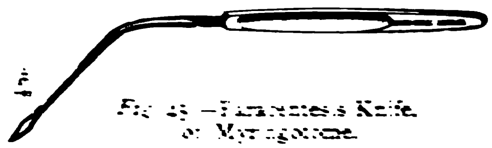

Fig. 45.—Paracentesis Knife, or Myringotome.

Treatment.—In the early stages, before perforation has taken place, everything should be done to cause *resolution* of the middle-ear inflammation, and avoid perforation. The patient should be put to bed, a sparing liquid diet prescribed, and a smart calomel purgative given. An ice-bag may be placed on the side of the head, but if the pain be great, hot, moist compresses may be more grateful. If mastoid tenderness be well marked, leeches may be put over the mastoid process, or in front of the tragus, or both.

If resolution do not take place within two or three days, or if bulging of the membrane be discovered by otoscopic examination, a free incision should be made by a paracentesis knife (*Fig.* 45) into the bulging part; or in the absence of bulging, into the postero-inferior segment of the membrane. Whether pus exude or not, this operation cannot do harm, and may prevent serious consequences. After the operation, a light gauze packing may be placed in the canal, and a dressing applied over the auricle.

The operation of **Paracentesis** of the tympanic membrane is not difficult, but it merits separate description. The largest speculum which will enter the external auditory canal should be chosen, and through it a local anæsthetic should be painted over the tympanic membrane by means of a fine cotton-tip. A mixture of equal parts of cocaine hydrochlorate, pure carbolic acid, and menthol suffices. Then a sharp-pointed myringotome (*Fig.* 45) is introduced through the membrane in its postero-inferior segment, and made to pass downwards and forwards in a curved line, nearly parallel with the attachment of the membrane towards and into the antero-inferior segment. The whole thickness of the membrane should be cut. This line of incision clears the ossicles, avoids the chorda-tympani nerve, and its force is spent on the lower and posterior part of the hard wall of the promontory. It may cross the rim of the round window, but cannot enter it, as this opening points downwards and backwards, and only its edge can be scored by the point of the knife. Unless placed unusually far forward, the jugular bulb is in no danger of injury. In the absence of a proper paracentesis knife, a tenotomy knife will serve the purpose well. After the incision, the pus may be removed by dry cotton-tips, or, if necessary, by the syringe. In children Politzerization, and in adults inflation through the catheter, may be used as a *vis a tergo* to evacuate the tympanum.

Before performing paracentesis, the external auditory canal should be rendered as aseptic as possible by antiseptic instillations (carbolic solution, peroxide of hydrogen, etc.), and subsequent thorough drying. After the operation, the pus should be removed by careful drying, often repeated, and if any nasal or naso-pharyngeal disease be present, care should be taken that no fresh infection be carried up the Eustachian tube by the instruments used for inflation.

If a perforation exist, the situation or size of which renders it insufficient for draining the middle ear, a probe-pointed myringotome should be passed through it, and with a downward stroke, the membrane should be incised to its lower border. The indication for such an operation may be the presence of pain in spite of the

occurrence of perforation, the bulging of the membrane into a cone, with a drop of pus oozing from its apex, or a small perforation placed so high up that thorough drainage of the middle ear is impossible.

The subsequent treatment of the disease should be carried out daily by the surgeon ; or if the patient must be entrusted with the treatment, he should be directed to dry the canal thoroughly with aseptic cotton-tips, and not to use the syringe. For the more thorough cleansing of the ear, the surgeon may use an instillation of warm peroxide of hydrogen, to disintegrate and loosen the flaky pus which gets plastered against the sides of the canal ; then the canal may be gently washed with a weak solution of carbolic or boracic acid, and subsequently left quite dry. The approach of healing is intimated by the lessening of the discharge, the diminution of mucus, and the disappearance of blood. Only when the discharge is very slight, is it wise to treat the case by *insufflations* of a dry powder, such as boracic acid.

The case must be treated to a finish under the eye of the surgeon, and on no account should an acute middle-ear suppuration be allowed to drift into a chronic condition. The nose and naso-pharynx should be carefully attended to. Often, the ear disease has arisen from a previous nasal or naso-pharyngeal disease. In particular, post-nasal adenoids should be looked for and thoroughly removed. Suppurative conditions in the nose should be treated by warm alkaline and antiseptic lotions. After the suppuration has ceased, gentle inflation should be practised till all trace of deafness has been removed, and any constitutional state (anæmia, tuberculosis, syphilis, etc.) which has favoured the development of the ear trouble, or might court relapses, should receive the attention of the practitioner.

Chronic Middle-Ear Suppuration.—The usual cause of this common and dangerous disease is an uncured *acute otitis media*, when the latter has been neglected ; or, chronic suppuration becomes established when the original middle-ear inflammation has been so severe as to affect deeper structures, such as the ossicles, the inner tympanic wall, the tegmen tympani, or the mastoid cells.

Chronic suppuration of the middle ear is dangerous both to hearing and to life. And yet it is seldom so regarded by its victim. He becomes accustomed to the condition, regards it as a slight nuisance, frets a little at the daily trouble of removing the discharge, but seldom treats it seriously, and hardly ever thinks he is in any danger. The importance, therefore, to the practitioner, of the diagnosis and treatment of this disease is all the greater, and his responsibility is correspondingly increased.

Chronic middle-ear suppuration alters the structures within and surrounding the tympanum very profoundly. The normal mucous lining of the cavity becomes replaced by granulation tissue. This may line the whole visible cavity of the tympanum, or it may be massed towards the roof of the cavity in disease of the attic, towards the postero-superior angle in disease of the aditus or antrum, or toward the floor or cellar, if the bone be affected in that region. It may arise from the neighbourhood of the Eustachian tube. This granulation tissue may proliferate so as to fill the inner end or the whole of the external auditory canal, and an aural polypus results. As a rule, a large part of the membrane is destroyed, and large perforations occupy the lower part of the membrane. The part of the membrane which longest withstands the destructive process is the upper part in contact with the ossicles, round which a rim is often left when all the rest of the drum-head has disappeared. The unsupported malleus handle is apt to become applied to the promontory, and to form adhesions there, whilst pus-filled pockets get more or less shut off towards the tympanic attic. The ossicles become necrosed, and their attachments loosened. One or all may be exfoliated, the incus most commonly, the malleus next in order of frequency, and the stapes least frequently. Thus the whole middle ear becomes emptied, and the entire membrane disappears, leaving a plain walled cavity (*Plate IV, Fig. K*). Did the necrotic process confine itself to the ossicles, healing would not be difficult at this stage. But the promontory, the tegmen tympani, the tegmen antri, or the bone in the substance of the mastoid process, often becomes diseased, and the foundation of a mastoid abscess, of an

intracranial abscess, or of a sinus thrombosis, is laid. The advent of these complications may be long deferred, but they often come with all the suddenness of an explosion.

Such a wholesale destruction or evacuation of the contents of the tympanum is quite consistent with the preservation of good hearing. If the fenestræ escape, and the stapes remain in position, and fairly movable, the loss of the membrane and of the two larger ossicles does not involve great loss of hearing. Less serious with regard to life, but often more destructive of the sense of hearing, are such results as the fixation of the ossicles by fibrous bands, the loss of the stapes, and the growth over the fenestræ of firm cicatricial tissue. The remaining pieces of membrane are apt to become opaque and calcified, or if regeneration take place, the new tissue is a scar formation from which the normal layers of the membrane are absent. Cessation of the discharge may take place and a dry perforation may result, or the epithelium of the external auditory canal may creep over the edges of the perforation, line the middle ear, pass into the mastoid cells or attic, and produce a *cholesteatoma*. In many cases the discharge is very slight, so slight that the patient believes the ear to be dry, until the formation of a hard crust causes pain, or a thick epithelial plug sets up irritation which compels him to seek relief.

In disease of the malleus a small perforation often takes place in Shrapnell's membrane. The rest of the membrane may be intact, the discharge so slight as to pass unnoticed; but a probe strikes the bare head of the malleus (*Plate IV, Fig. E.*).

Such are the conditions present in a chronic middle-ear suppuration commencing in measles or scarlet fever, or arising out of an acute otitis media. The destructive processes are sufficiently extensive, but in *tuberculous* children the destruction of bone is even more extensive. The disease begins during the period of dentition, and may cause rapid necrosis in the mastoid and petrous portions. Sequestra form in the mastoid process, or the whole capsule of the labyrinth may be exfoliated. The Fallopian canal is often eroded or included in the necrotic mass of bone, and the facial nerve is destroyed.

PLATE

IV.

KEY TO PLATE IV.

Figs. A, B.—Normal Tympanic Membrane. Pale slate colour or parchment appearance, lustre good; the triangle or spot of light is seen to project downward from near the tip of the handle of the malleus.

Fig. C.—Small Perforation of Tympanic Membrane. The ear is wettest at night, when the patient lies on the affected side, and the perforation is thus properly placed for drainage.

Fig. D.—Healed Perforation. There was a history of suppurative disease during childhood.

Fig. E.—Perforation in Shrapnell's Membrane. Through the perforation the probe easily touches a necrosed ossicle—probably malleus. Healing followed without operation.

Fig. F.—Pus Exuding from a Perforation in Tympanic Membrane. The bead is replaced immediately it is wiped off with a cotton-tip, and the membrane bulges a little. After free incision of the membrane, healing followed rapidly.

Fig. G.—Double Perforation of the Tympanic Membrane. A case of middle-ear suppuration of several months' standing.

Fig. H.—Multiple Perforation in the Tympanic Membrane. No search was made for the bacillus of tubercle, but there have been no painful symptoms, and there are other evidences of the tuberculous tendency in the case.

Fig. I.—Destruction of the Tympanic Membrane. Only a rim is left. The handle of the malleus projects into the cavity of the tympanum. The internal tympanic wall is bare. Suppuration is slight, but has lasted for many years—since measles in childhood.

Fig. J.—Destruction of the Tympanic Membrane, Scarlatinal Otitis Media. The whole membrane is gone except a small portion held by the malleus, The discharge is very slight, but the probe strikes the bare bone of the inner wall.

Fig. K.—Destruction of the Tympanic Membrane, Scarlatinal Otitis Media. The tympanic cavity is empty of the membrane and ossicles. The dark depression is probably the fenestra rotunda.

Fig. L.—Granulation Masses in the Tympanic Cavity. These filled up almost the whole inner end of the external auditory canal. No membrane existed. After removal of the masses, healing took place without the radical operation. A necrosed ossicle was extracted.

Fig. M.—Granulation Masses in the Tympanic Cavity. There is no membrane. The masses recurred after removal. The radical operation will be required, or at least an ossiculectomy, for a necrosed incus can be made out.

Fig. N.—Granulation Masses in the Tympanic Cavity. Discharge began after scarlet fever six years previously; the upper and back mass was found at the radical operation to project through the tegmen antri, and to lie against the dura mater.

PLATE IV.

PERFORATIONS AND DESTRUCTION OF THE TYMPANIC MEMBRANE.

A.

B.

C.

D.

E.

F.

G.

H.

I.

J.

K.

L.

M.

N.

The SYMPTOMS of this disease are few and inconspicuous. Except some slight headache, which is more pronounced when retention of pus takes place, there is little pain. There is often itching in the external auditory canal, and in children this is apt to take the form of an eczema, which may affect the auricle, and side of the head and face; and the glands about the neck are often enlarged. There is often tinnitus, but this is not constant, and it is never of the distressing character which makes chronic aural catarrh so unbearable. The hearing is variously affected. There is usually some dullness, but it is astonishing how much destruction of the membrane and ossicles may take place without great impairment in hearing. Both the tinnitus and the deafness seem to be greater, where cicatricial changes have bound down the ossicles or caused inward pressure of the foot-plate of the stapes. There may be perversion of taste if the chorda tympani nerve be involved, but though the facial nerve is often exposed, facial paralysis is uncommon unless in extensive caries or necrosis.

The otoscopic appearances are very varied, as may be concluded from the great variety of pathological changes which have already been referred to. It may be difficult to discover any perforation. When it is quite clear that the lower part of the membrane is intact, and presents nothing or almost nothing abnormal, attention should be directed to Shrapnell's membrane. There, a very small perforation with very little discharge indicates to the observer where, by the help of a probe, he may discover caries of the malleus. A perforation high up and behind, similarly leads the probe, in many cases, to a diseased incus. But most perforations are in the lower part of the membrane, and here they may assume almost any shape, and may be single or multiple. Small perforations are usually circular in shape, and except in caries of the ossicles, are usually placed in the lower part of the membrane and surrounded by membrane. They may be multiple, and if the disease causing multiple perforations have been painless in its origin and course, a tubercular cause may be suspected. Small perforations may also be slit-like when they occur at the edge of the tympanic membrane, near the tympanic ring.

Large perforations may be circular, but when very la shape is determined by the limits of the free membrane i they occur. The handle of the malleus often projects dow into a large, otherwise circular perforation, and makes the of the latter kidney-shaped. The whole membrane may b except that held in the grip of the malleus, this remainin consisting of two crescentic portions passing respectively bac and forwards to the upper part of the tympanic ring, and ponding to the anterior and posterior folds of the membrane. these may be gone, and if the malleus remain intact, its stands out in strong relief in the otherwise empty tympanic or becomes applied to the wall of the promontory, where it i form adhesions. Lastly, the ossicles may be exfoliated, remaining parts so pulled up into the tympanic attic that cases of extensive destruction of membrane, the whole t cavity seems empty, and otoscopic examination displays but the red or pale granulation-lined internal tympanic which the promontory can be mapped out, and a slight v the destroyed membrane can be detected at its periphery r tympanic ring (*Plate IV, Figs. I, J*).

But the tympanum from which ossicles and membr thus disappeared may not be empty. It may be fi granulation masses. Even where much of the membran such masses may be detected within the tympanic cavity a large perforation. They may spring from any part of of the middle ear. The commonest source is either or the postero-superior angle near the aditus. But t spring from the cellar of the tympanum, or the region of th of the Eustachian tube in front, and they should always probe of the surgeon to their base in search of diseased b *IV, Figs. L, M, N*).

Having found the perforation, a probe should be passe it. There need be no hesitation about using a probe fre middle ear. Under a good light no harm can be done, this sinus should not have applied to it the valuable test o

present writer cannot see, although some aural surgeons hedge proceeding about with many conditions and precautions. If were shut up to the use of one instrument in examining a case of onic middle-ear suppuration, he would lay down the mirror and eculum and take up the probe; but he is not advocating the use only one instrument. Under a good light, and with as large speculum as the canal will admit, let the probe be employed oroughly. It may be used with a straight or with a curved tip, ut never with a sharp point. Practically, the only structure one can njure is an exposed facial nerve, and a blunt-pointed probe will not injure the nerve. The attachment of every granulation mass should be tested, the ossicles should be tested, the curved tip should be turned upwards into the attic, upwards and backwards into the aditus ad antrum, and downwards into the cellar of the tympanum. It is from these two first points that granulations generally spring, and at which polypi find their attachment, and here, in most cases of chronic middle-ear suppuration, the probe hitches against unhealthy bone. If a granulation mass be large enough to obstruct the view of the middle ear, and occupy the lumen of the external auditory meatus, it may be necessary to remove it before a diagnosis can be made. This will be more fully discussed under the heading of aural polypi.

If discharge have ceased, a dry perforation may remain, and through this may be discovered by the speculum, the cicatrized internal tympanic wall. Or, if the perforation have become closed by a cicatrix, the latter will present itself as a patch of altered colour, bluish and glistening, or whiter than normal, and apparently thickened (*Plate IV, Fig. D*). Whether the perforation be closed or not, whitened patches of calcareous material are often found in the remaining parts of the tympanic membrane. Cicatricial bands may bind down a perforated or a healed membrane to the promontory or to the ossicles. When the membrane is intact, inflation by Valsalva's method or Politzerization may be used to display the condition of the membrane. The non-adherent parts may sometimes be ballooned out, whilst the adherent parts remain tied down to the

structures to which they are attached. Or, if the scar be not adherent, it may bulge more than the sounder parts of the membrane. In the same way Siegle's speculum may be used to ascertain the condition of the altered scar-marked but intact tympanic membrane.

PROGNOSIS.—If it be the case that this disease so often involves the mastoid cells and tympanic attic, our expectations with regard to any treatment short of a radical operation will not be sanguine. These adnexæ cannot be properly drained without free opening up of the bony recesses which compose them. On the other hand, if practically every case can be cured by the help of the radical operation, the prognosis and the treatment will be correspondingly modified. In giving a prognosis, the condition of these recesses is of the first importance. If the disease has lasted several years, and if it has originated in scarlet fever or measles, it is not likely that mere washing and drying, however thoroughly done, will effect permanent stoppage of the discharge. If removal of granulation masses be followed by their reappearance in spite of careful cleansing, it is almost certain that nothing short of a radical operation will effect a cure. On the other hand, if the disease has not originated in a virulent cause like scarlet fever or measles, and especially if there be no granulation masses springing from the upper and back part of the middle ear, careful syringing and drying often end in cessation of the discharge. The mere striking by the probe of the bare internal tympanic wall, or of a necrosed ossicle, is not enough to warrant a bad prognosis. Such affection of bone at the anterior and lower part of this wall towards the upper end of the Eustachian tube is very common, and generally yields to proper treatment short of operation, and, in any case, no operation on the mastoid would do anything to cure disease in this situation. Bad odour of the discharge is of unfavourable prognosis.

In young children affected with the dentition type of otitis, whether the destructive process be extensive or not, the disease is usually tubercular, and the prognosis bad. But even here the radical operation greatly increases the patient's chances of recovery,

and, unless tubercular disease be suspected elsewhere, a favourable opinion may be given as to the result of operative treatment.

As long as discharge lasts, even to the slightest extent, the patient must be regarded as suffering from a condition which at any moment may seriously threaten his life.

With regard to hearing, the prognosis should be guarded. Generally, the cessation of discharge is followed by improvement in hearing; but as the deafness in this disease depends not on the amount of destruction of membrane and ossicles discovered by otoscopic examination, but on the amount of fixation of the stapes within the foramen ovale, and on the changes in the labyrinth itself, the amount of the improvement cannot be predicted.

TREATMENT.—The indications for treatment are: (1) The complete removal of all the products of inflammation from the suppurating cavity; (2) The thorough drying of the suppurating cavity; (3) The dressing of the suppurating cavity; (4) The prevention of re-infection of the healing or healed cavity.

1. *Cleansing and drying the Tympanic Cavity.*—The middle ear, when diseased, is an ideal breeding-chamber for any micro-organisms which have reached it. There is a uniform temperature, and there is plenty of moisture. One cannot alter its temperature, but the external auditory canal forms a patent sinus through which the tympanum can be cleansed and dried. Were the latter a plain walled cavity, without pockets and recesses, and did the tympanum not pass at right angles into the attic and into the mastoid antrum, drying, and drying alone, would be a sufficient means of cleansing it. But the emptying of an attic or an aditus ad antrum filled with pus and cheesy masses, by means of cotton-tips, however skilfully used, is impossible. So that in many cases the use of lotions as ear-baths or by the syringe is a great advantage, and if thorough cleansing is to be effected, an absolute necessity. On the other hand, there is no doubt that the syringe is often used by the patient, and sometimes by the surgeon, when it does no good and may do harm.

2. *Drying of the Suppurating Cavity.*—When the perforation is small and the discharge is slight, as in the small perforations in

embrane, thorough drying of the external auditory u mpanic membrane, with the subsequent insufflation a dry powder like boracic acid or aristol, is the best treatment. cases do not require to be dressed often. A crust grows over perforation, and in a week or a fortnight, or when caking of the powder and discharge causes pain, by the pressure of the resulting dry crust, the crust may be removed by a sterilized cotton-tip, and the drying and insufflation repea . Or if this be difficult or painful, a warm solution of perox f hydrogen instilled into the ear or used with the syringe, w ach the crust and make its removal easy. Under this treatment he necrosed ossicle (malleus) may gradually become healthy, the discharge stop, and the perforation heal, unless a cholesteatomatous mass exist in the tympanic attic.

The same treatment can be carried out in the tympanic cavity through a large perforation, or where no membrane exists at all. But if the attic or the aditus ad antrum be filled with pus, drying alone will be insufficient. In these cases some form of intratympanic syringe (*Figs*. 30, 31, page 89), the nozzle of which can be directed upwards or backwards in the direction of the pus-filled pockets, is very useful. Siegle's speculum, too, may be helpful in sucking discharge from these recesses.

Any granulation masses occupying the middle ear, or projecting into it from surrounding recesses, should be removed, either by a cold wire snare, a small curette, or some form of biting forceps. Curetting the attic, however, is not unattended by danger. If a granulation mass project from the attic, its attachment may be through a perforation in the tympanic tegmen to the dura mater.

3 *Dressing the Tympanic Cavity*.—Except after an operation, where serous discharge and bleeding are copious, or in cases where there is hardly any discharge at all, the wearing of a long cotton wick or a packing in the middle ear, should be avoided. Such dressings soon become saturated with pus, and form a good soil for the generation of micro-organisms. After careful dressing and drying of the drum cavity, the outer end of the external auditory canal

should be stopped by a small piece of sterilized cotton-wool, which may be renewed from time to time, or removed so that cleansing may be repeated. Re-dressing should be done as soon as discharge begins to fill the inner end of the meatus. On no account should discharge be allowed to trickle to the outer end of the meatus, else an eczema may be set up, and the middle ear may be infected from without by a more virulent type of micro-organism. The patient, if he must be entrusted with the dressing, may test his ear by means of a clean cotton-tip to ascertain when re-dressing is necessary; the surgeon must satisfy himself by examination with the mirror and speculum.

If such dry treatment be not followed by improvement and ultimate healing, various medicaments may be tried. Powders containing iodoform and boracic acid often set up a serous discharge

Fig. 46.—Insufflator.

from the middle ear, or cause a violent eczema. When used, powder should be introduced by means of an insufflator (*Fig.* 46). Probably boracic acid has held too high a place in the estimation of most aural surgeons for the last twenty years. Its action should always be watched, and the drug, whether as powder or in solution, be withdrawn when eczema or profuse discharge has followed its use. The instillation of alcoholic solutions often lessens discharge and promotes healing, when associated with careful cleansing and drying. But the alcohol should be thoroughly applied. The ear having been cleansed and dried, the patient must, either by Valsalva's or Politzer's method, have the upper part of the Eustachian tube emptied, and the additional discharge removed by means of a cotton-tip. With the head inclined to the sound side, the affected ear has 5 to 10

drops of rectified spirits of wine instilled into it, and for ten or fifteen minutes the patient must let this soak into the ear, Valsalva's inflation being used several times with the head thus inclined and the spirit occupying the external auditory canal. The patient then raises his head, and empties the excess of spirit from the meatus, and the surgeon may re-dry the ear before applying the cotton plug.

From time to time during such treatment as has been indicated, exuberant granulation masses may have to be removed by snare (*Fig.* 38), curette, or forceps (*Fig.* 47). It is much better to deal with these growths thus, than by a caustic or by the galvano-cautery. It is difficult to limit the area of action of caustics and of the cautery. If, however, a caustic be used, perhaps chromic acid is the best.

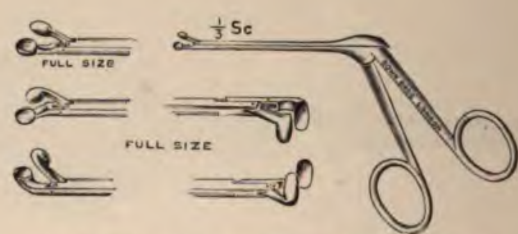

Fig. 47.—Hartmann's Sharp Spoon Forceps.

It can be applied accurately by means of a fine cotton-tip, and its action can be instantly stopped by a solution of bicarbonate of soda.

A mild form of the caustic treatment consists in giving an ear-bath to the whole tympanic cavity, consisting of a 5 per cent solution of nitrate of silver, the solution being kept in the ear five to ten minutes, and then washed out with sterilized warm water. This treatment is only fitted for large perforations, through which all the albuminate of silver formed can be thoroughly removed by the current of water, and it should not be repeated before the eschar or scab formed has come away. Any stains left on the side of the face by the silver solution should be wiped off by a solution of iodide

of potash. After three or four such applications of this silver treatment, Politzer secures healing in some obstinate cases of granulation lining of the middle ear, which do not heal by the dry method or by the alcoholic treatment.

As an adjunct to cleansing by the external auditory canal, washing out the middle ear through the Eustachian tube may be tried. Any weak antiseptic solution can be employed. Much of the fluid used passes into the pharynx, a few drops only, as a rule, making exit by the external auditory canal. Probably Politzerization, associated with syringing and careful drying of the middle ear in the ordinary way, is as efficient as this method of treatment, and it is less disagreeable to the patient.

Such treatment—in the absence of urgent symptoms—should be continued for a long time, and before success is attained the patience of both patient and practitioner may be severely tried. A long list of remedies will suggest themselves. All kinds of antiseptics, stimulants, and astringents have been employed. Boracic acid, iodoform, peroxide of hydrogen and alcohol, and nitrate of silver, have been mentioned. Carbolic acid, salicylic acid, formalin, sulphate of zinc, tannic acid, sulphurous acid, and other remedies have been tried, and successes have been reported as the result of their use. But the desire to possess such a variety of remedies is an evidence of weakness, not of strength, on the part of the practitioner. It is the thorough cleansing, the careful drying and dressing, and the intelligent appreciation of the causes of failure, which make for ultimate success in the management of chronic suppuration of the middle ear.

4. *Prevention of Re-infection of the healing Cavity.*—The management of the external auditory canal has already been alluded to. In addition to the drying out of the canal with sterilized cotton-tips, the auricle should be scrubbed occasionally with methylated ether, so that the surroundings of the healing wound may be as nearly aseptic as possible. All cotton-holders should be sterilized after use by passing their ends through the flame of a spirit lamp, and all aural specula, forceps, etc., should be carefully

sterilized by boiling. Otherwise, not only will healing not proceed, but attacks of acute otitis media and externa will mar the history of the case. But re-infection takes place also from the throat. The naso-pharynx, the Eustachian tube, and the nose and throat require attention. The removal of post-nasal adenoids often permits the healing to take place which cannot be brought about by a succession of astringent lotions, or even by the most careful toilet of the middle ear by the practitioner. The same remark applies to enlarged tonsils, to inflammation of the pharynx, and to chronic rhinitis, all of which conditions are attended by infection, which readily spreads up the Eustachian tube to the ear. At the same time the use of alcohol and tobacco in any form should be interdicted. These, by setting up or keeping up a reddening of the fauces, do harm, and render secondary affections of the middle ear more probable.

The general health of the patient must not be forgotten. Tonics, change of air, and other general measures have their uses in the management of this, as in all other chronic suppurations, but the careful local treatment is of the first importance. The writer once met an Englishman in Switzerland who hoped to return to London free from an aural discharge, which in the meantime had become extremely fetid, and for the local treatment of which his medical attendant had scarcely given his patient even a hint. Cure was expected to follow the change of air!

Operative Treatment.

When healing does not follow this careful treatment of the middle ear, some part of the bony walls of the tympanum, or an ossicle, is diseased, or there is retention of the products of suppuration in the mastoid process. How long are we to wait before proposing operation? Various terms have been set for this less heroic treatment, ranging from a year or more down to three months or less. Assuming that the patient puts himself entirely in our hands, we should propose operation as soon as we have *proof* that a careful toilet of the middle ear has not been

followed by satisfactory improvement. In particular, if granulation masses have been removed, and have reappeared, no more time should be wasted over preliminary treatment. There are two procedures, which offer themselves to the surgeon for the cure of these cases of obstinate middle-ear suppuration: firstly, *ossiculectomy;* and secondly, *opening up the tympanic attic,* or *mastoid cells,* or both. The latter operation will be discussed in the next chapter; but the operation of ossiculectomy may be described here.

Ossiculectomy.—The operation of ossiculectomy in chronic middle-ear suppuration differs from that indicated when the membrana tympani is intact, in several important particulars, these latter varying according to the changes produced in the middle ear by the suppurative process. Little of the tympanic membrane may be left, and the ossicles, or what remains of them, may be so retracted into the tympanic attic that their discovery is not easy, and their removal difficult. On the other hand, the disease may be solely or chiefly in the attic, and the ossicular attachments there may be so loosened as to render removal easy. One or more of the ossicles may be absent, either in whole or in part, or the heads of the malleus and incus may be fixed or ossified into one mass. The incus is most commonly diseased, and most commonly exfoliated. Lastly, the ossicles—usually the long process of the malleus—may have formed fresh attachments to the structures within the middle ear, and removal may be rendered difficult from this cause. The plan of the operation in chronic middle-ear suppuration must therefore vary according to the diseased conditions present, and great care must be taken not to break ossicles which are already diseased, and thereby rendered brittle.

The parts in this disease have been rendered hypervascular, and the operator must count on greater difficulty from bleeding than when the operation is made on an intact membrane. Usually, it is wise to detach the malleus from its strong anterior and external attachments, by a sharp-pointed knife introduced in the direction of the attic. When the bleeding from this incision has ceased, under the influence of pressure by a cotton tampon, or with the additional

help of adrenalin chloride, the remaining part of the membrane must be dealt with. If the perforation be large, the incus present, and the incudo-stapedial articulation visible, this ossicle may be disarticulated. But the incus is often absent, oftener diseased even when present, and the joint may be involved in the disease. So that what remains to be done before extraction by forceps, is to complete the detachment of the membrane behind and in front of the incision already made into the tympanic attic. This is done, either by entering the perforation with a probe-pointed knife, and cutting round the margins of the membrane, first upwards and forwards, and then upwards and backwards, till the circle of the incision is complete, or by beginning at the incision above and ending with the perforation. The malleus is then seized just below the short process, with a crocodile forceps or a Sexton's forceps (*see* p. 159) and dragged first downwards and then outwards. The incus must now be carefully searched for with the help of an incus hook, and if present removed (*see* p. 159). It may be already displaced towards the antrum, or the manipulations of the operator may cause this displacement. Further, it may be attached by ossific processes to the malleus. All this must be borne in mind in drawing conclusions about an incus which has not been found. Before dragging on the malleus with the forceps, it is well to make sure that the handle of this ossicle is free from the promontory, and if it is not, to divide by an angular knife any cicatricial attachment which has been formed in this situation.

Such is the operation for removing the malleus and incus in inveterate suppuration of the middle ear. The stapes is usually left, both in this operation and the more radical mastoid operation. But the cario-necrotic process is not usually confined to the ossicles. The promontory is often affected, the margin of the tympanic ring near the aditus almost as often, and patches of diseased bone sometimes exist in the cellar of the tympanum and at the upper orifice of the Eustachian tube. Such limited cario-necrotic patches must be dealt with along with disease of the ossicles. The edges of the tympanic ring in the upper and back part of the tympanum

(external attic wall) may be removed, either by sharp spoons or by the punch forceps. The latter instrument is the better, and bites away the softened bony edge, thus giving better access to the attic and aditus during subsequent treatment (*see Fig.* 48).

The ossicles may be removed after the method of Stacke, which will be described in the next chapter, along with the mastoid operation. If the disease for which the ossicles are to be removed involve also the tympanic ring and the tegmen tympani, Stacke's method is much the more suitable. It gives access to the attic and antrum, both of which are under the eye of the operator, and is safer than the application of curettes to the tegmen tympani. The principle of Stacke's operation is, that by removal of the inner end of the postero-superior wall of the bony meatus, the attic and aditus are exposed, and the ossicles removed by the post-auricular wound, the making of which is a necessary preliminary to the operation on the bone.

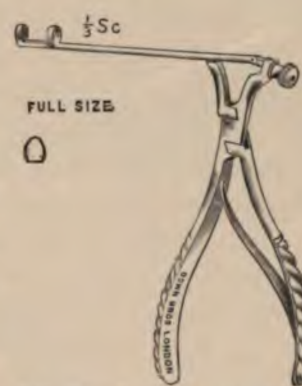

Fig. 48.—Punch Forceps for Outer Attic Wall.

Ossiculectomy, as a means of curing a chronic middle-ear suppuration, is followed by better results than the same operation performed for the improvement of hearing and the cure of subjective auditory sensations in non-suppurative middle-ear catarrh. But it has a limited application even in chronic middle-ear suppuration. The mere removal of the ossicles is not a procedure attended by any danger, but the caries which renders the removal of the ossicles a proper surgical procedure, is generally not limited to these bones, but affects also the external attic wall, the aditus ad antrum, and the tegmen tympani; and the most thorough, as well as the safest operation for such a condition, is not the removal of the ossicles *via* the external auditory canal, but the radical mastoid operation, during which all the diseased structures are exposed to the surgeon's eye, and can be thoroughly examined and safely dealt with. It is

a significant fact that, after the radical mastoid operation, the superior and posterior aspects of the wound, that is, the parts towards the aditus and the tympanic attic, nearly always heal, whilst after an ossiculectomy these are the parts which continue to give trouble. It is certainly neither a safe nor a scientific procedure to attempt to cure by ossiculectomy disease of the attic, one evidence of which is the sprouting of granulation masses from the tegmen tympani. The curette used in removing such masses from the attic is apt to do harm instead of good. This subject will be discussed when considering the mastoid operation and the indications for performing it (*see Chap. VIII*). In the meantime it may suffice to indicate the conditions warranting ossiculectomy, and thus to set the limits for its performance. Ossiculectomy in chronic middle-ear suppuration is indicated in the following conditions :—

1. *Caries* of the malleus or incus, with loss of the greater part of the tympanic membrane, in cases where there is no evidence of involvement of the mastoid antrum.

2. *Perforation* of the membrane of Shrapnell, with a high degree of deafness, even if the tympanic membrane be otherwise intact. Here, the deafness indicates that the disease is more extensive than the mere perforation would lead one to expect, and removal of the ossicles may stop suppuration and cannot further damage hearing. On the other hand, if hearing be good, the disease according to Politzer is generally limited to the external attic wall, and the treatment should be conservative.

3. In *Cholesteatomata* of the attic, where the ossicles obstruct the discharge, or render the cleansing of the attic by the intra-tympanic syringe impossible.

On the other hand, if granulation masses project from the tympanic roof, and especially if these recur after removal, ossiculectomy is not a sufficiently radical operation.

It is so seldom that one can absolutely exclude mastoid involvement in obstinate middle-ear suppuration, and the mastoid operation is so safe, and so certain to remove the risks of future intra-cranial complications, that, in all cases where any doubt exists

as to the condition of the mastoid antrum, the radical operation should be preferred if the consent of the patient can be obtained. It is of course assumed that, before ossiculectomy is proposed as a means of curing middle-ear suppuration, one of two conditions is present: either that all less radical means have been patiently tried and have failed, or that it is clear that less radical means are useless. In the presence of urgent symptoms, ossiculectomy is only a waste of time, and the radical mastoid operation should be done at once.

Artificial Membrana Tympani.—When suppuration has ceased, if hearing be so deficient that the patient can only conduct his business with difficulty, an attempt may be made to improve his hearing by the application of some form of the so-called artificial membrana tympani.

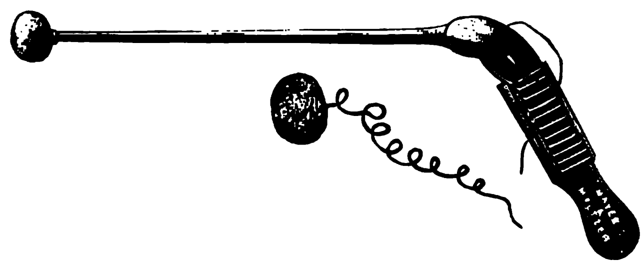

Fig. 49.—Yearsley's Artificial Membrana Tympani and Forceps.

In 1841 an American merchant communicated to Dr. Yearsley of London, the fact that he was able to improve his hearing temporarily by the application to his middle ear of a spill or small roll of paper. Yearsley acted on the hint, and substituting moistened cotton-wool for paper, applied the so-called artificial membrane which bears his name (*Fig.* 49). In 1853, Toynbee used a disc of rubber, fixed to the end of a fine wire by which the disc could be introduced into the middle ear. Other modifications of these appliances have been tried, but it seems more important to indicate the principle on which they all act, than to describe

every variety of them. Probably they never operate quite similarly to normal membranes. They are not stretched membranes, and cannot vibrate like tense membranes. Probably they act in two ways. They carry sound-waves to the structures (ossicles) next the internal tympanic wall, and they support those structures, and restore to some extent the normal conditions of tension at the foramen ovale.

In practice, one can seldom predict the effect on hearing of the application of an "artificial membrane" within the middle ear. The writer's best results have been in cases of large perforations, where the ossicles, and particularly the stapes, are exposed, and where through the perforation a small cotton pellet could be placed against the unsupported ossicle. Several trials may require to be made with regard to the size and position of the pellet, before the best result is reached. A little practice makes the patient more expert than the surgeon in the application of the pellet, but at first it should be worn only for a few hours at a time, and it had better be removed at night. As a rule, the cotton pellet acts as well as the rubber disc, and it is less liable to set up subjective noises, and is otherwise better borne by the patient. Before application, the cotton pellet should be moistened by a weak antiseptic solution or by parolein. A thread about an inch and a half long is attached to the pellet to facilitate its extraction. It is introduced by a pair of forceps, as shown in *Fig.* 49.

If discharge increase under the cotton pellet, it must be removed and its use discontinued.

AURAL POLYPUS.

Reference has been made to the need—both in thorough examination and in treatment—for removing granulation masses which, in cases of chronic middle-ear suppuration, spring from the tympanic cavity. When such a mass not only fills the drum cavity, but pushes itself outwards into the external auditory canal, it is called an aural polypus.

On the possession by the practitioner of sound views as to the

nature of aural polypus, depends in every case his success in dealing with the affection, and in many cases, his power to save the life of his patient. If he regard the growth as merely a thing to be removed, and when it recurs—as it is almost sure to do—to be removed again, he will have no real success in his work; and connected with one of his attempts at removal, or during one of the seemingly quiescent periods after removal, acute symptoms will occur which may carry off his patient. On the other hand, if he regard the polypus merely as an accident in the suppurative process, and its removal merely as the preliminary to the more thorough treatment of the cause in the middle ear, his treatment of the polypus will meet with real and final success, and the risk to his patient will be greatly lessened, or disappear altogether.

An aural polypus, then, is a *granulation mass*, springing from the walls of the middle ear or the external auditory canal, projecting into and taking the form of the canal, and varying in composition from a soft, mucous, almost gelatinous mass, to a firm fibrous growth. The growth may be so long as to project at the outer end of the meatus, and this projecting part may be dry, and covered with a pale, skin-like layer composed of altered epithelium. The deeper parts within the canal are usually moist, and bathed in pus. The attachment is commonly pedunculated, so that the whole growth is pear-shaped, the apex being inwards towards the middle ear. In structure, aural polypi are either round-celled, or they are fibromata, and between these, various gradations occur. The surface of the polypus is often indented or lobulated like a gland, and in the interior, cystic or other degenerative changes may occur. Tubercle bacilli have been found within the substance of aural polypi. The soft, round-celled polypi may grow rapidly; the polypi into which fibrous tissue enters largely, grow much more slowly.

Polypi may be single or multiple, large or small. Generally they spring, either from the upper and back part of the middle ear, or the inner tympanic wall; most commonly the former. They have usually the significance of a granulation mass near or in any other

sinus, viz., that caries or necrosed bone exists in the vicinity. If a mastoid abscess have burst into the external auditory canal from the border cells, a polypus may originate at the mouth of the resulting sinus; but unless this, or some other similar suppurative focus, exist within the canal, the origin may be sought for within the middle ear. It is not always easy to determine the point of origin, but a probe, passed between the growth and the wall of the canal, will in most cases indicate the attachment of the pedicle. It should be remembered that a granulation mass or polypus may have its attachment, through an erosion of the tegmen tympani, to a diseased dura mater.

The SYMPTOMS of aural polypus are not conspicuous. Unless the growth hinder the exit of pus, and cause retention, there is no pain. The discharge is often profuse and sometimes fetid. There is deafness, of course—the deafness due to the causative disease in the middle ear, *plus* that due to the obstructing mass in the meatus. Tinnitus is often a result of polypus.

The PROGNOSIS is not that of the polypus, which is easily removed, but that of the middle-ear suppuration, which it may be impossible to remove except by radical operation. It should therefore be guarded, and should be accompanied by the advice that mere removal of the growth itself is not likely to end in cure.

The TREATMENT of aural polypus is immediate and thorough removal, followed by treatment of the suppurative process in the middle ear, until all discharge has ceased.

The best means of removal is the cold wire snare (*see Fig.* 38), or a pair of narrow-bladed forceps. The point of attachment having been determined by means of a probe, the forceps should be passed inwards, and the growth grasped as near the neck or pedicle as possible, when by a twisting or screwing movement the growth will be brought away entire. Or if the snare be used, a loop, small enough to pass through the lumen of a large speculum, should be passed over the growth, and gradually inserted as far towards its attachment as possible, when, by tightening the loop, severance at the neck takes place. The loop often comes away without the growth, but if the

neck have been cut, a current of water from the aural syringe will float the growth into the receiving vessel. Bleeding after removal of aural polypus is free, but does not last long. Still, it is often necessary to suspend the operation at this point, and deal with the stump, or other smaller growths, at a second sitting.

The removal of smaller granulation masses is best effected by the curette, or by such instruments as Hartmann's sharp spoon forceps (*Fig.* 47). These instruments, accurately and skilfully used, remove even the smallest growths, and do not, like caustics, leave a necrotic mass behind to delay and complicate healing. If, however, a mass present itself which cannot be removed by instruments, it may be touched with chromic acid or other similar caustic.

All these operations on granulation masses are rendered easier for the surgeon and less painful for the patient, if a strong solution of cocaine have been previously instilled, or if the parts have been previously touched by the cocaine-menthol-carbolic mixture. For the control of bleeding, one of the preparations of suprarenal capsule may be used just before the operation, or a pressure-plug of cotton may be worn for a few minutes. After the operation, a small ear packing should be inserted, until the stage of bleeding and serous discharge is over. The subsequent treatment is as for chronic middle-ear suppuration. Preparations containing alcohol probably tend to prevent recurrence, and shrivel the stumps of masses which have been removed.

TUBERCULOSIS WITHIN THE TEMPORAL BONE.

During the preceding description of middle-ear suppuration, reference has been made to the disease as occurring in association with certain constitutional states, such as tuberculosis and the infectious fevers. Both the symptoms and the pathological changes in these forms of middle-ear suppuration are distinctive enough to warrant a special notice.

Tubercle of the middle ear may be either primary or secondary. The latter is probably much the commoner of the two sets of cases, but recent investigation seems to point to the conclusion that

primary tuberculosis of the middle ear is much commoner than has been hitherto supposed. When the disease is secondary to tuberculosis in other parts of the body, phthisis pulmonalis is usually the primary condition. Such cases are of course commonest in adults, and in these, the destructive processes within the temporal bone are much less extensive than in the tuberculous middle-ear affections of children. Of course, all middle-ear suppurations in phthisical patients are not tuberculous. In children, post-nasal adenoids are probably a common cause of tuberculous middle-ear suppuration. Milligan found that sixteen per cent of the post-nasal adenoids he examined were of a tuberculous nature. In the poorly-fed, badly-housed children of large cities, middle-ear tuberculosis is apt to appear during the period of dentition, to progress rapidly, to destroy large parts of the temporal bone, to cause paralysis of the facial nerve, and to cause enlargement and ultimate breaking-down into pus of the lymphatic glands surrounding the ear.

The results of tuberculosis on the temporal bone and its contents are very marked. The membrane rapidly breaks down in one or in several places. If the perforations are multiple, they soon coalesce and destroy almost the whole of the membrane, the ossicles become necrosed, and their ligamentous attachment loosened, so that they are readily exfoliated, in whole or in part. The walls of the tympanic cavity and those of the mastoid antrum and cells become eroded, the mucous membrane being lost; large portions of the temporal bone become necrosed and form sequestra; the dura mater over the tegmen tympani and tegmen antri may be exposed and the mastoid process become reduced to a friable shell; pus bursts out most readily on the surface of the mastoid process, and sinuses result. Sinuses also form readily on the internal tympanic wall, and the internal ear may become involved. Compared with the extent of the destructive process, the intra-cranial structures are implicated with comparative rarity. Meningitis is the most common intra-cranial complication.

Clinically, the features of temporal bone tuberculosis are, the

rapid destruction of the tympanic membrane, the enlargement of the glands about the ear and in the neck, the occurrence of facial paralysis, which happens in about half the cases, and the presence of a little discharge, which may either be thin in character and of a creamy colour, or may be mixed with curdy masses, and may have a bad smell. The hearing may be very greatly damaged, and if there be involvement of the internal ear, bone conduction is greatly reduced. On the other hand, there is *hardly ever any pain*—a feature of the disease which, when the extent of the destructive process is considered, is very remarkable, and which explains how this disease is so often overlooked or thought lightly of.

If the mirror and speculum be used in the early stages of the disease, before perforation has occurred, the tubercular character of the case may be indicated by grey tubercle nodules being seen through the membrane. If the perforations have taken place, but the resulting necrotic areas have not coalesced, several perforations may be seen corresponding to such nodules. Later, the appearances are those of very extensive destruction of the tympanic membrane, and the probe strikes the bare internal tympanic wall (*Plate IV, Fig. H.*).

The DIAGNOSIS is not difficult when the disease occurs in a young child, and is accompanied by facial paralysis, enlarged glands, and a history of the absence of pain. But in other cases it may be necessary to search for the tubercle bacillus, or even to perform inoculation experiments before a diagnosis can be made. The bacillus is not easily found in the pus, for other micro-organisms soon enter the field, the infection becomes mixed, and the newer microbes gain the upper hand. The discovery by the probe, however, of extensive bony involvement without the history of an acute disease like scarlet fever or measles, and the absence of a history of pain in the ear, should make the surgeon suspect a tubercular cause, even if the surrounding glands be not involved, and the facial nerve be sound. If these two signs are added to the clinical picture, the case hardly admits of a doubt.

The PROGNOSIS is bad if there be tuberculosis elsewhere; fairly

good if the disease be *limited* to the temporal bone. Even if the dura mater be exposed, almost the whole of the temporal bone in its petrous and mastoid portions necrosed, and the facial nerve paralysed, recovery may follow thorough operative treatment. Much depends on the general health of the patient, and on the treatment of the case by good food and fresh air after the operation.

The TREATMENT, in cases suitable for operation, consists of the evacuation of all purulent collections of pus from the glands round the ear, and, either at the same time or at a later date, the opening up of all the cavities of the temporal bone, as will be described when treating of the mastoid operation. In advanced cases of phthisis, with secondary involvement of the middle ear, operation should, if possible, be avoided. In children, post-nasal adenoids should be removed if they are present.

EAR DISEASE IN THE ACUTE INFECTIOUS FEVERS.

This will come to be discussed in connection with acquired deaf-mutism, which is so often due to the infectious fevers. It may be noticed here, that the suppurative conditions which have been considered in this chapter, are of a more vicious type and less amenable to treatment than when such specific causes are absent. The tendency to destruction of the bone is great in the middle-ear suppurations which accompany the infectious fevers. On the other hand, the acute mastoiditis which follows scarlet fever is very amenable to surgical treatment. It is *chronicity* which is to be feared here, as in other middle-ear suppurations.

The ear discharge which accompanies this type of disease is capable of carrying the specific infection for a very long time. In a case of the author's in which he performed the mastoid operation for an acute mastoiditis following scarlet fever, the ear discharge proved to be infectious in the thirteenth week after the onset of the disease, long after desquamation from the surface of the body was finished.

INJURIES TO THE ORGAN OF HEARING.

When the ear is injured, more than one of its divisions may suffer, so that it is convenient to consider injuries to the organ of hearing in one place. *The auricle* may be injured either by blows or by pulling on its substance. Blows cause abrasions and blood tumours; pulling may injure the auricle, or may tear the tympanic membrane in its upper and posterior part, which is continuous with the skin of the inner end of the external auditory canal.

The external auditory canal is often injured by pins and other sharp bodies which are used for picking the ear. The inflammation thus set up may spread to the bony walls of the canal, to the inner end of the canal (tympanic membrane), or to the mastoid cells. Attempts to remove foreign bodies by means of sharp instruments, even when carried out by skilful hands, may cause injury to the walls of the external auditory canal, perforation of the tympanic membrane, and the driving of the foreign body into the middle ear. The aural syringe, when used with soda or other alkaline solution, becomes slippery to the fingers, and unless provided with a prominent edge, rings, or projecting crutches, the barrel may slip suddenly from the fingers, and the point of the nozzle may injure the walls of the meatus, or may even perforate the tympanic membrane. Falls upon or severe injuries to the lower jaw, may fracture the anterior wall of the external auditory canal.

Injuries to the *tympanic membrane and structures within the middle ear* may occur in various ways, viz.: (1) From blows on or about the auricle; *e.g.*, that of a fist to the side of the head, or of a hammer to the mastoid process; (2) From the penetration of a sharp body through the membrane *via* the external auditory canal; *e.g.*, the driving of a crochet pin into the ear; (3) From the sudden condensation of the air in the inner end of the external auditory canal by a loud sound occurring near the ear; *e.g.*, the firing of a cannon; (4) From the extension of a fracture of the base of the skull through the roof or anterior wall of the tympanum and through the tympanic membrane.

[illegible]

[illegible] and very loud sounds—[illegible] of the membrana tensa between the umbo and [illegible]. They may be oval or round. [illegible]. The symptoms of traumatic [illegible] of a very loud [illegible], with or without [illegible] soon after the [illegible] covered with blood, and [illegible] the result of disease—an [illegible] may follow in time.

4. In *fracture* of the base of the skull, extending into the middle ear and membrana tympani, the aural symptoms may be inconspicuous, or quite masked by the cerebral symptoms; but if the meninges have been torn, cerebro-spinal fluid may be mixed with the blood which flows from the ear.

Actual fracture into the labyrinth is not common, the capsule being composed of firm bone, round which rather than into which, the line of fracture goes. This line of fracture is usually through

the weakest part of the petrous portion—from the jugular foramen across the tegmen tympani et antri.

The effect on hearing of traumatic rupture of the tympanic membrane is not usually great. When great deafness results, and is permanent, hæmorrhage into the labyrinth has probably occurred, and the usual hearing tests will differentiate the condition. Unless bleeding into the labyrinth has occurred, all the symptoms soon begin to pass off, and the perforation tends to heal.

The TREATMENT of traumatic ruptures of the membrane is by rest and quiet, and the avoidance of all local applications of a moist kind. The canal may be gently cleared of excess of blood, and a sterilized cotton plug should be left at its outer end; but the syringe should not be used, no solution should be dropped into the ear, and insufflation of powder is not at all necessary. Healing takes place as a rule, without suppuration, but if this latter should occur, it must be treated on the lines already laid down.

If intra-cranial or intra-labyrinthine damage be suspected, rest in bed must be insisted upon, and the possibility of a meningitis due to infection from without, borne in mind. When coma passes off and danger to life seems over, the deafness, tinnitus, and giddiness must be treated, as will be indicated under labyrinthine hæmorrhage (*see Chap. X*).

From the number of cases which come before the practitioner, it seems still necessary to protest against the practice of boxing the ears by the teachers of children. In those who have had suppuration of the middle ear, even slight injury of this kind is sufficient to re-establish the discharge. Practitioners should avoid the too violent use of the Politzer bag in cases in which the tympanic membrane has been weakened or thinned by disease, as the membrane in such cases may not only be ballooned out, but ruptured from the side of the middle ear.

Caisson Disease.—Sudden changes of air pressure result in distressing symptoms referable to the ear, sometimes in bleeding into and from the middle ear, and occasionally in permanent deafness. Such symptoms are experienced in their milder forms

CHAPTER VIII.

COMPLICATIONS OF MIDDLE-EAR SUPPURATION.

Special conditions attending Suppurative Inflammation within the Temporal Bone—Acute Mastoiditis—Chronic Mastoiditis—Indications for Opening the Mastoid Process—The Mastoid Operation—Management of the Soft Parts in the Mastoid Operation—Skin Grafting—Stacke's Operation—Delayed Healing after the Mastoid Operation—Risks of the Mastoid Operation—Cholesteatoma—Caries and Necrosis.

THOSE complications of middle-ear suppuration which occur within the tympanic cavity, have been already noticed. Such are aural polypus, granulation masses, disease of the tympanic ossicles, and cario-necrotic processes of the walls of the cavity. But it is not within the tympanum that the most serious complications of this disease occur. When neighbouring structures are attacked, the attack is delivered most commonly in one of two directions—upwards towards the middle fossa of the skull, or backwards towards the mastoid antrum and cells. The movement in the mastoid process may be but a step in a more serious attack on the contents of the posterior fossa of the skull, the cerebellum and the sigmoid sinus. Occasionally, too, the labyrinth is attacked from the side of the middle ear. Here again is a channel by which, at a later date, the posterior fossa of the skull may be reached by an infective process—the internal auditory meatus.

MASTOIDITIS.

The Attack on the Mastoid Process.—In acute suppuration of the tympanum, the mastoid cells are often if not always involved. There is tenderness to pressure over the mastoid process, and pain felt over the side of the head, but felt with greater severity in the

mastoid process. When the abscess in the middle ear bursts, the mastoid pain is relieved. The amount of discharge is often great —out of all proportion to the capacity of the middle ear—and in many cases represents the secretion of the aditus ad antrum. The communication between the tympanum and mastoid antrum is often short, direct, and wide; sometimes narrow and easily blocked. Little wonder therefore need there be, that infection passes towards the antrum. But the mastoiditis—if it may be so called—which accompanies acute suppuration of the tympanum, does not usually last. Unless the micro-organisms causing it be of a very virulent type, or unless the aditus be so narrow as to make drainage difficult, there is no reason why it should last.

It is otherwise, however, when the mastoid cells are extensively involved, when the drainage by the aditus is obstructed, or the opening in the membrane is too small. Then an acute mastoiditis may result. The nature of this mastoid inflammation will be determined not only by the conditions above indicated, but by the virulence of the micro-organisms present in the causative condition, *e.g.*, scarlet fever, diphtheria, influenza, etc. During a chronic middle-ear suppuration the advent of acute symptoms may be due to the blocking of the aditus either by a cheesy or a granulation mass; hence *lessening* or *cessation* of the middle-ear discharge may coincide with the onset of the acute symptoms. A middle-ear suppuration may cease, the perforation in the membrane heal, and at a later date the retained products in the mastoid cells may become active and give rise to a mastoiditis, which though really secondary seems to be primary. True primary mastoiditis, apart from injury to the mastoid process, is very rare.

Acute Mastoiditis.—THE SYMPTOMS are those of pus under pressure within hard bony walls. There is constant or remitting pain, made worse by pressing with the thumb or finger over the mastoid process. The pain under pressure may be worse towards the tip of the process, or over its centre; it is often localized at a spot. There is usually fever; high in children, and accompanied by vomiting, convulsions, and general disturbance, but in adults

not necessarily high, unless meningeal irritation be present or a sinus infection be in progress. As the surrounding parts become involved the soft tissues over the mastoid process become œdematous, brawny, red, and greatly thickened, and the ear stands out almost at right angles from the side of the head (*Fig.* 50). The aspect of the case, when the surgeon examines from behind the head of the patient, is very striking, and when it is present, the projecting auricle and œdematous swelling are of great diagnostic value; but it should not be forgotten that pus may exist within the mastoid process without causing any apparent alteration in the overlying soft parts. By the help of the speculum, the postero-superior wall of the external auditory canal, or the postero-superior quadrant of the tympanic membrane, may be discovered to show bulging; but, as with tumefaction of the external parts, these pressure signs sometimes discoverable with the mirror and speculum, may be absent, and yet the mastoid process may contain pus.

Fig. 50.—Mastoid Periostitis.

The course of an acute mastoiditis depends, in the early stages, on that of the acute otitis media of which it forms a part. If naturally, or by paracentesis, free drainage from the middle ear can be got, and if pus do not already exist in the mastoid cells, resolution takes place rapidly; but if the drainage be insufficient, and especially if there be present at the same time the more malignant micro-organisms—as in scarlet fever, influenza, etc.—an abscess within the mastoid process will form. Even then absorption of the pus may take place; but a commoner result is destruction by a cario-necrosis of the substance of the mastoid process, the formation of granulation masses, and the rupture of the abscess

on the surface of the mastoid process. Next in order of frequency is perforation of the postero-superior wall into the external auditory canal; and the least common perforation is towards the median surface of the mastoid process into the digastric groove (Bezold's mastoiditis). Only occasionally does an acute mastoiditis of recent origin extend into the cranial cavity and give rise to a meningitis, a sinus thrombosis, or a brain abscess; but the writer has seen it do so without pain in the mastoid process, or any objective mastoid sign of any kind.

Mastoid Periostitis.—Should perforation of the shell of the bone occur, the pus dissects up the periosteum from the bone, a sub-periosteal abscess is formed, and fluctuation is added to the other signs present. Should this abscess perforate the soft parts, a probe introduced by the point of rupture will, with some care, be made to enter a sinus in the bone itself.

Sub-periosteal abscess may, however, arise apart from perforation of the external surface of the mastoid process. In children the squamo-mastoid suture is a pus-channel by which infection reaches the periosteum, and the smaller blood-vessels which pass from the surface of the mastoid process through the supraspinous fossa, form constant channels of infection. Further, in middle-ear affections, and even in such affections of the external auditory canal as furunculosis and diffuse otitis externa, pus may pass backwards, dissect up the periosteum from the bone, and form a collection on the surface of the mastoid process.

The symptoms of mastoid periostitis are those of an acute mastoiditis, *plus* the physical signs due to the changes in the soft parts. The former are pain and fever; the latter a characteristic swelling and displacement of the auricle, best seen, when fully developed, from behind (*Fig.* 50). At first the soft parts over the mastoid process are thickened, swollen, and œdematous, but do not fluctuate; the auricle projects a little more than normal, and the skin over the mastoid process is reddened a little, and thrown into longitudinal folds. Later, after pus forms and fluctuation is added to the signs, the auricle projects very markedly outwards

and forwards, and the whole side of the head viewed from behind looks larger (Fig. 50). The fluctuation is confined to the mastoid surface proper, but the surrounding edema may extend forward to the side of the face, upwards over the zygomatic region, and downwards into the neck. For a time fluctuation may be difficult to make out; but soon the skin becomes red, and then the pus approaches the surface, and fluctuation is easily made out.

Chronic Mastoiditis has less striking symptoms than those belonging to the acute disease. Pus may exist in the mastoid process for years, without any painful symptoms being present at all. Destructive processes within the bone, extending over a long period, and essentially altering the structure of the mastoid process, may proceed without any conspicuous sign. The cells may become filled with pus, so that the whole process is one abscess sac, granulation masses may fill up the cells, erosion of the bony plate between the cells and the sinus wall may occur, cheesy masses may fill the antrum and contiguous spaces, sequestra may form within the substance of the mastoid process, without any well-marked symptom or sign. It is when retention occurs, by blocking of the aditus by secretion, that acute symptoms set in. In these chronic cases the perforation in the membrane—except those in Shrapnell's membrane—is generally so large, that the drainage from the middle ear is sufficient. But polypi, granulation masses, etc., which, during the course of a middle-ear suppuration, have developed within the tympanum, may cause retention and determine the occurrence of acute symptoms. In the same way ceruminous masses, exostosis, and other obstructions in the external auditory canal may become determining factors. The more extensive destruction of bone within the substance of the process makes the chance of an intra-cranial complication greater than is the case in a recent acute mastoiditis.

When such retention takes place the SYMPTOMS are not essentially different from those in acute mastoiditis. There is acute pain, and there is tenderness on pressure over some part of the bone. There may be swelling of the soft parts, reddening of

the skin, projection of the auricle, and the formation and rupture of abscess, just as has been described in the acute disease. Fever, giddiness, vomiting, and other symptoms may also be present. With the speculum a more extensive destruction of membrane is seen than in recent acute mastoiditis. Granulation masses often project from the upper and back part of the drum cavity. Pus may be seen to trickle from this neighbourhood or, if there be no fluid discharge, cheesy *débris* may sometimes be washed out of the attic and aditus by the current directed from an intra-tympanic syringe. If the abscess have burst through the border cells into the external auditory canal, a swelling like a boil may be seen on the soft parts there, or if these latter have yielded before the pressure of pus, a sinus will exist through which the probe will detect the diseased bone.

The commonest situation for spontaneous rupture of an abscess formed during the course of a chronic mastoiditis is the external surface of the process. Rupture into the external auditory canal is fairly common, into the digastric groove rare, but commoner than in acute mastoiditis. Erosion of bone between the cranial cavity, and infection of the intra-cranial contents, is much commoner in chronic then in acute mastoiditis.

Diagnosis.—During the acute attacks which occur in the course of a chronic mastoiditis the diagnosis is pretty easy, but between these acute attacks, and in those latent cases in which no acute symptoms occur, the diagnosis is difficult. Even where the patient has never complained of pain in the mastoid process, it may sometimes be elicited by the firm pressure of the thumb. When it is thus elicited its presence is an important positive sign, but its absence does not negative the diagnosis of pus within the mastoid process. Still, pain is an important symptom, and its presence, or the tenderness which is elicited by pressure, may be the only indication for an operation which, if postponed, may have to be performed for an established brain complication.

The following case illustrates this point. Three years ago, during the writer's holiday, he was sent for to see a girl then eleven

years old, who had been seized with acute pain in the mastoid process. In his absence a mastoid abscess was opened by another practitioner. In December, 1903, the girl was brought to the writer with headache, referred to the side which had been operated on. There was tenderness over the mastoid process. Within twenty-four hours her first menstruation appeared, and all headache left, but the tenderness to pressure remained. Otoscopic examination showed a very tiny perforation of Shrapnell's membrane, from which the smallest quantity of evil-smelling discharge could be removed on the tip of a cotton probe. On the strength of the single symptom of pain on pressure, the operation proceeded. The first chip of the chisel revealed pus under the surface of the mastoid process, the periosteum of which was however quite adherent. The surface of the bone was quite normal, and quite unmarked by any former operation on the bone. When the wound in the bone was widened, the purulent mass was found to be so nearly solid that it could be shelled out almost unbroken, and to occupy the whole mastoid process from the tegmen antri to the tip of the process. The communication with the upper part of the tympanic cavity by the aditus was very narrow. The bony wall between the posterior mastoid cells and the sigmoid sinus was quite absent, and the latter was exposed for nearly an inch in length and half an inch in breadth. The radical operation was completed, the posterior meatal wall split, the mastoid wound stitched, and complete healing of the large cavity in the mastoid process took place in about five weeks.

Tenderness to pressure over the mastoid process in the course of a chronic middle-ear suppuration may exist, although no collection of pus be within the antrum or cells. In cases of sclerosis of the mastoid process this pain often exists, and is due doubtless to the changes within the substance of the bone itself; similar indeed to the pain produced in a syphilitic node.

In the absence of pain on pressure, evidence of the presence of pus within the mastoid process may be got by the discovery of a sinus in the external auditory canal communicating with the

mastoid cells, or by the help of Siegle's speculum, or an intra-tympanic syringe, a large quantity of pus or of cheesy material may be removed from the upper and back part of the tympanic cavity. This sign has been already noticed, but it has a special significance in cases of latent mastoiditis. Another guide of importance in these latent cases is the recurrence of granulations after careful removal from the upper and back part of the tympanic cavity, or from the tympanic roof. Percussion and auscultation of the mastoid process have been advanced as a means of determining the nature of its contents.

Percussion is carried out in the usual way. Mastoid auscultation is practised in the following way. An ordinary rubber tube, such as is used in making an auscultation tube, or such as forms part of a bin-aural stethoscope, is furnished at one end with an ear-piece to fit the ear of the surgeon, and at the other with a small metal or vulcanite terminal, shaped like an aural speculum. This latter is placed over the antrum of the suspected mastoid process, and, while the surgeon listens, a tuning-fork is sounded on the top of the head or on the bridge of the nose of the patient. A pus-filled antrum is supposed to modify the sound which passes through it, so that it differs from that arriving at the surgeon's ear through an air-filled antrum, and thus gives evidence of diagnostic value. Two such tubes may be used at once if the surgeon can trust his ears to be alike, or one tube may be used and alternately placed on the two mastoid processes of the patient.

Although a study of the physical conditions present would lead one to expect definite and accurate information from this method, in practice it is not often of value. The writer took a series of skulls and excavated the mastoid process on one side, leaving the other intact. Into the excavated mastoid he then in one skull ran molten lead, in another some marmalade, and into a third he put some cotton-wool. The results were not definite enough nor uniform enough to make him expect much of mastoid auscultation as a means of diagnosis. On the other hand, in a case of Bezold's mastoiditis on which the writer operated lately, a definite

result was obtained. In this condition the mastoid cells are diseased down to the tip of the process, and abscesses are present amongst the muscular planes on the side of the neck. In the case in point the sound was decidedly greater at the tip of the affected mastoid, but not increased over the antrum, and the operation showed the antrum to contain little or nothing, whilst the cells towards the tip were filled with inflammatory exudation. Probably extended application of this test will define its position and value; but in the meantime it should be used only as an auxiliary, and one can hardly see that in any case it will be of such importance as to enable the surgeon to decide on a line of treatment without the most careful consideration of the other facts of the case. The mastoid antrum may be so small and the other cells so few that, though they be so hopelessly diseased as to render operation necessary, no auscultatory difference can be detected; and it is probable that the skull, which may be called the sounding-board in the experiment, is so large with regard to the cavities of an ordinary mastoid process (the resonating chamber in the experiment) that uniformly reliable results cannot be counted on.

The PROGNOSIS in *acute* mastoiditis is good, if the causative disease be of recent origin, and if free drainage can be got from the middle ear on the one hand, and the pus-filled mastoid cells on the other. Time has not elapsed in these recent cases for the occurrence of cario-necrotic erosion of the tegmen tympani et antri, or of the bony wall separating the sigmoid sinus from the mastoid cells, so that intra-cranial complications are rather rare.

In *chronic* mastoiditis, on the other hand, the prognosis should always be guarded, especially if it is necessary to interfere during the occurrence of pain and fever. These symptoms may mean intra-cranial infection already in progress. But the prognosis is good so far as life is concerned, if operative interference be carried out during a period of quiescence; and if cario-necrosis of the tympanic walls does not exist, it is likely also that cessation of discharge will in time occur.

TREATMENT.—In an *acute mastoiditis* of recent origin, an attempt

should be made to anticipate impending pus-formation within the mastoid process, by opening the bulging tympanic membrane in its postero-superior quadrant, or by enlarging any small perforation which already exists. If the case be in its very early stages, cold may be applied over the mastoid process by means of a Leiter's coil. Later on, great benefit may be got by the application of leeches to the mastoid process, or to the face in front of the tragus. If discharge be very profuse it may have to be removed by syringing, a warm sterile salt solution or a weak antiseptic lotion being used. A deep *incision* behind the ear over the mastoid process, carried through the periosteum down to the bone—called a Wilde's incision—will, if pus have not already formed in the mastoid cells, influence the case favourably just as leeching does, but it must not be allowed to take the place of an incision in the membrane for the establishment of proper drainage, nor the place of the operation on the bone itself. In addition to these local measures, general treatment should not be neglected. The patient should be kept in bed, and perfect quiet be insisted upon by his nurse. Diet should be fluid, and for the most part cold or cool. A smart calomel purge followed in a few hours by a saline, should also be administered.

In a mastoid periostitis with pus-formation, or even œdema and swelling which has not yet gone the length of pus-formation, free incision down to the bone is the only measure worth considering. Even this is, as a rule, only the first step to a more extensive operation on the bone itself; but it may be wise to defer the latter for some days, to permit of the subsidence of swelling of the soft parts. Such postponement is, however, only justifiable, if there be no acute symptoms indicating the need for immediate operation on the bone.

In *chronic mastoiditis* there is much less scope for non-operative treatment, and almost the only reason for continued treatment without operation, is doubt that the mastoid antrum and cells contain pus. Granulation masses and polypi should be removed by snare or scraper, any necrosed ossicle taken away, and the fluid discharge or cheesy masses extracted by suction or

intra-tympanic syringing. In the absence of acute symptoms there is no limit to the time over which such treatment may be spread; but if granulation masses recur, if discharge from the attic or antrum does not diminish, and particularly if attacks of pain occur in the mastoid process, there is no reason for postponing indefinitely the opening of the mastoid process. During the course of such treatment the conviction will grow upon the observant surgeon, that his task without opening the bone is a hopeless one. It is convenient here, however, to tabulate the **Indications for Opening the Mastoid Process.**

1. *In Acute Mastoiditis.*—Broadly speaking, these are the failure of the palliative and expectant treatment already described to produce resolution of the mastoid inflammation. If, after two or three days, failure attend less heroic treatment, operation should be carried out at once. In particular, the persistence of high temperature or the occurrence of rigors, indicate the need for immediate operation. The absence of mastoid pain or of tenderness on pressure, should not deceive the surgeon and lead him to hope for a good result by waiting longer. In the meantime, a meningitis or a sinus phlebitis may be in progress, and the only hope for the patient is the removal of infective material from the mastoid cells.

2. *In Chronic Mastoiditis* the following are indications for operation:—

(*a*) The recurrence of granulation masses in the attic or antrum in spite of continued treatment by cleansing.

(*b*) The recurrence of painful acute attacks in the mastoid process during the course of a chronic middle-ear suppuration.

(*c*) Fever, vomiting, and other symptoms indicative of meningeal irritation, occurring during a middle-ear suppuration, even if there be no pain or tenderness of the mastoid process.

(*d*) A sinus over the mastoid process, and the discovery by the probe of cario-necrotic processes within the substance of the bone.

(*e*) The removal by suction or by intra-tympanic syringing of pus, cheesy masses, or epidermic *débris* from the attic or antrum,

and the inability on the part of the surgeon to bring about cessation of such discharge by prolonged careful treatment.

(*f*) Fœtor of a middle-ear discharge, and the discovery of cario-necrotic spots within the cavity of the middle ear.

(*g*) Retention of pus within the middle ear, due to narrowing of the external auditory canal, or to exostosis almost closing its lumen.

Whether in a middle-ear suppuration, without definite proof of the presence of pus within the mastoid process, but in which careful treatment continued over a long period has failed to stop the discharge, the surgeon should propose the mastoid operation, is a difficult question about which to lay down any general rule. The surgeon who has patiently carried out the palliative treatment is best fitted to give advice in the particular case before him. Often there will grow up in his mind a conviction that nothing but a radical operation will succeed; and this conviction cannot be set aside as valueless, even in the absence of reasons which cannot be easily defined. Before deciding, there will come before his mind on the one hand, the many cases of middle-ear disease, some of them having occasional attacks of pain in the mastoid process, which have lasted many years or even half a life-time without causing the death of the patient; and on the other, the not uncommon case of the same disease, which without any mastoid pain or other warning symptom, has suddenly blazed out into a meningitis or sinus thrombosis, and carried off his patient before his eyes. Truly the owner of a chronic mastoiditis sits on the edge of a volcano. Looking to the *safety* of operative interference on the one hand, and the *risk* attending an uncured middle-ear suppuration on the other, it can hardly be said that the attending surgeon has done his duty by his patient unless he give the latter the chance which operation offers.

THE MASTOID OPERATION.

There are various operations on the mastoid process, and that adopted in any particular case must depend upon the object the surgeon has in view, and the local conditions present. But, as the

plan and extent of the operation have in many cases to be decided after the contents of the mastoid process have been displayed, it is convenient to treat the mastoid operation as an evolution from the simple to the complex, and consequently to deal with it as a whole, and to describe it in one place. As this specific evolution, happening daily in the individual case, is a repetition of the historical evolution of the radical or complete mastoid operation, it will be well to look shortly at the history of the mastoid operation.

History of the Mastoid Operation.—The mastoid process was first opened surgically about the middle of the eighteenth century. For over a hundred years the importance of this procedure was little appreciated, and no advance towards the more thorough methods of the present day was made.

In 1873, Schwartze, of Halle, first performed the operation by which the mastoid cells are made to communicate with the middle ear. This must be considered the most important development in the evolution of the mastoid operation, for two reasons. It removed immediately, and in many cases permanently, the pent-up septic material which, unless removed, must sooner or later give rise to serious complications; and it made subsequent evolution of the operation itself certain.

In 1889 Kuster laid the basis of the modern radical mastoid operation. He proposed to remove the posterior wall of the bony meatus, so as to expose fully all the affected cavities of the middle ear and mastoid process. Stacke proposed to reach the affected cells within the mastoid process by chiselling away the inner end of the posterior meatal wall, and thus reaching the antrum after having opened up the attic.

Combinations of these methods may be adopted, but the principle underlying all modern methods is, that by removal of the posterior meatal wall, the external attic wall, and of all overhanging ledges and diseased partitions within the mastoid process itself, all the cavities involved—the tympanic cavity, the tympanic attic, the mastoid antrum, and all communicating cells—are reduced to

one smooth-walled bony cavity, so shaped and drained that rapid and final healing of the wound will take place.

There are three grades or stages of the mastoid operation.

1. *The opening of the mastoid abscess,* and the removal of any diseased bone or cell contents, such as pus or granulations.

2. *The opening of the mastoid process, and of the mastoid antrum,* the bony partitions towards the antrum being thus removed.

3. *The radical operation* in one of its forms, by which the tympanic cavity, the tympanic attic, the aditus and mastoid antrum, are reduced to one smooth-walled cavity, of as simple a shape as possible. This operation involves the removal of the posterior wall of the meatus, the outer wall of the attic, and of all bony ledges which overhang the antrum.

Which of these operations he will perform the surgeon cannot always fix beforehand, but the findings during the earlier stages will determine his further conduct.

Instruments and Preparation.—The following instruments are necessary for the mastoid operation. A strong medium-sized knife; a sharp-pointed and a probe-pointed bistoury; a pair of dissecting forceps; several pairs (six or eight at least) of pressure forceps; a periosteal elevator; a large rake-like flap retractor; a right-angled retractor for the external auditory canal; several chisels and gouges ($\frac{1}{8}$- to $\frac{1}{3}$-inch broad); a curved dressing forceps; a narrow sinus forceps; a short hammer with a heavy leaden head; several pairs of aural or crocodile forceps for catching the ossicles; needles and sutures; bent and curved probes; a Stacke's guide or protector for the facial nerve; several small scrapers or sharp spoons; a pair of bone forceps for biting away overhanging edges of bone (*see Fig.* 56); and a series of iron wire cotton-holders for drying out pockets in the bony wound. In addition, a set of electrically driven burrs should be at hand. These are used for smoothing bony walls and shaping the mastoid cavity after chiselling is finished. The writer sometimes uses a guide or protector for the facial nerve, which differs from that of Stacke. The beak of the guide, instead of being prolonged in the direction of the handle, is turned outwards

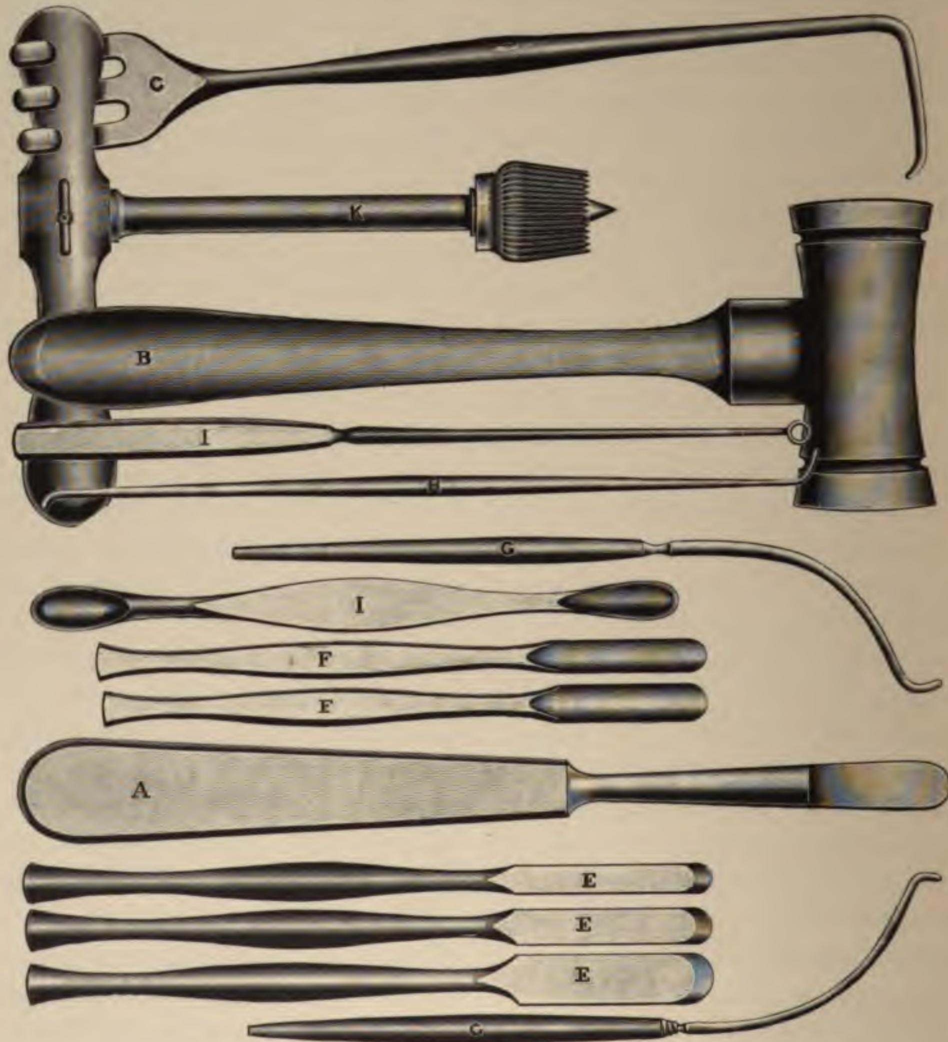

Fig. 51.—Set of Mastoid Instruments (about $\frac{3}{4}$ size).

(A) Periosteal elevator. (B) Hammer. (C) Double-ended retractor. (E) Chisels. (F) Gouges. (G) Right and left modified Stacke's protector for facial nerve. (H) Double-ended searcher, or measuring probe. (I) Curettes. (K) Trephine. These instruments are all contained in a metal pocket case, which hinges between (G) and (H). Case made and fitted by Weissner, Renfield Street, Glasgow.

at an angle of about 30° with the handle. This modification necessitates a right and a left guide, but it is easier of introduction, and during its use the hand of the assistant lies on the neck of the patient and does not hide any facial twitching (*Stereogram XXVII*).

On the day before the operation the hair near the mastoid process, or indeed over the half of the head, should be removed by a razor, and the skin should be thoroughly cleansed with soap and water, followed by methylated ether. Likewise the external auditory canal should be thoroughly cleansed, dried, and plugged with a sterilized gauze ribbon. A sterilized dressing should then be applied to the side of the head, and should not be removed till the time of operation.

The Operation.—An incision is made from the tip of the mastoid process, parallel with and about a quarter or an eighth of an inch behind the attachment of the auricle, and is made to curve forwards in its upper part to a point near the upper end of the attachment of the auricle to the side of the head. All along its length, except at the upper part, which is curved forward, the knife must pass through the periosteum, and lean on the bone itself. The bleeding is apt to be profuse, but the bleeding points can be caught temporarily by pressure forceps. Next, a periosteal elevator is made to strip the periosteum forwards and downwards, till the postero-superior wall of the external auditory canal is laid bare. This must be done carefully, and at first not too deeply, in case the inner end of the cartilaginous meatus with the attached tympanic membrane be injured. The periosteal elevator may then be made to strip the periosteum backwards, but unless the incision have been made quite close to the auricle, not much periosteum has to be raised in a backward direction. The edges of the wound thus made in the soft parts are now kept apart by three- or four-pronged retractors, and the surface of the mastoid is exposed, with the following land-marks: The supra-meatal or Henle's spine, the supra-spinous fossa, the postero-superior wall of the bony external auditory canal, the linea temporalis or supra-mastoid crest, and the flat surface of the mastoid process—the *planum mastoideum.*

The surgeon must now define for himself what his objective is—the opening of a collection of pus in the substance of the mastoid process, generally due to a recent acute mastoiditis; the finding of the mastoid antrum; the opening of the tympanic attic; or the thorough laying together of all the recesses in the mastoid process and those in the middle ear.

For the mere opening of the mastoid cells, in a case of recent acute mastoiditis, a few chips with the chisel and hammer are often sufficient. These are applied just behind the external auditory meatus, on the flat part of the mastoid process. The writer at one time used a perforator for searching the mastoid process. It consisted of a piercing point with a shoulder an eighth of an inch from the tip, and with it he found pus within the mastoid, and even found the mastoid antrum, with great rapidity. Although no accident occurred in over a hundred applications of this instrument, he has almost given up its use, because, in the event of its being used in a case where the sigmoid sinus bent very far forwards towards the external auditory canal, damage to the sinus might occur.

If a sinus already exist in the bone, entrance to the abscess cavity must be sought through this opening. Having found the abscess cavity, widening must be carried out by means of chisel and hammer, or better still, if the bone be not too hard, by means of the sharp spoon. The friable diseased partitions between the mastoid cells yield easily before moderate pressure. Granulation masses, too, are easily evacuated in the same way. Great care, however, is necessary in proceeding backwards, in case the sinus be injured, and the probe or the searcher (*H. Fig.* 51) should be constantly in the hand of the operator, for use in testing any suspicious-looking object. Merely laying bare the sinus wall does no harm, and has the advantage of telling the operator something of the condition of the vessel and its contents. Accidental puncturing of the vessel, especially before its environment has been cleared of pus and other diseased products, is an accident of the most serious nature. With a bent probe, the mastoid cells should be searched towards the tip of the process, and also in an upward direction towards the antrum.

No diseased cell should be left unablated, and the scraper should be used in every direction until resistant healthy bone is reached.

Opening the Mastoid Antrum.—If the previous examination of the case has determined the surgeon to open the mastoid antrum, and if no sinus on the surface of the mastoid process or in the postero-superior meatal wall gives him a lead towards this cavity, he must depend on the anatomical landmarks already described (*p.* 213) for guidance of his movements. If the membrane in its upper and back part have been destroyed, if the incus be necrosed or have been exfoliated, a probe with a short right-angled bend (a fourth of an inch from its tip), or a Stacke's guide, may be hooked into the aditus ad antrum, and the situation, and sometimes even the size of the antrum, indicated with precision. But if the operation be in any degree exploratory in its character, and particularly when—as in a case where both ears are affected—it is desirable not to damage the hearing, it is better not to introduce instruments into the aditus *via* the middle ear, until the extent of the disease within the mastoid process has been ascertained. The antrum must therefore be sought from the external surface of the mastoid process.

This is done by chipping the postero-superior meatal wall with sharp chisels and gouges, beginning above and behind the spine of Henle (the supra-meatal spine), and proceeding inwards to the necessary depth till the antrum is discovered. The supra-meatal spine is to be included in the bone removed. Above, the line of chiselling must not pass the supra-mastoid crest. Behind and towards the tip of the mastoid process, the wound must be widened, in order to make manipulations in the forward and deeper part of the bone wound easier, but in these directions—behind and towards the tip—the sides of the bone wound should shelve towards the surface, so that the sigmoid sinus may not be injured. Sometimes the antrum is large, and found near the surface of the bone; often it is small and so deeply placed as to suggest to the surgeon that it has been obliterated or is absent. But this conclusion should not be readily accepted by the operator. Except in one

f ier operations, where the antrum was certainly
sn where he lacked courage, the writer has never failed
er e mastoid antrum.

searchi for a small, deeply-placed antrum in an eburnated process, the operator needs both faith and boldness. If the hooked probe into the aditus, and proceed slowly along postero-superior meatal wall, he will be rewarded. The chief ger in this progress is lest the chisel wound the facial nerve, h lies in the lower and interr f the mass of bone form- posterior wall of the ex ory canal. It is therefore u r and external part of th of bone which must be oved by the chisel. In other w t is the upper part of the sterior meatal wall, and the outer wall, which may be safely removed.

Once the antrum has been found, th hooked probe should be made to enter it through the mastoid w und, and its limits should be defined. In particular, the distance to the tegmen antri above should be measured, and that backwards to the sinus wall should also be estimated. The ledges of bone overhanging the antrum above and behind should now be removed by the chisel, and all spaces which can be discovered in the bone towards the tip of the mastoid process must be opened up, if they are suspected of containing pus.

Should the surgeon now wish to complete the **Radical Mastoid Operation,** he must turn his attention to the remaining bridge of bone, which separates the mastoid wound behind from the middle ear and external auditory canal in front. After having thoroughly opened the antrum, and ablated all diseased cells and pockets within the mastoid process, this bridge may still form a considerable thickness of bone. It contains in its lower and inner aspect the Fallopian canal in which runs the facial nerve. The bridge must therefore be cut in its upper half towards the tympanic attic. With the help of the measuring bent probe and the Stacke's guide, this is not difficult and is quite safe. The dura mater may be exposed, but if the chisel be held at right angles to the side of the

head it will not readily be cut. Once the whole outer attic wall has been removed, and the upper border of the wound in the bone forms a plane at right angles to the side of the head, widening in an upward direction should cease. But in its deeper parts the bony wound may be much too narrow for thorough examination of the lower part of the tympanic cavity, and may be badly shaped for the application of flaps and growth of skin. The lower part must therefore be carefully widened. This is best done by the chisel, proceeding from below upwards and inwards, parallel with and not across the direction of the facial nerve. During the whole operation on the deeper part of the bone, but particularly at this stage of it, an assistant should be asked to watch for facial twitching. This sign is always noticed when the nerve is injured slightly, but may be wanting if it be suddenly cut through. Hence the importance of having the edge of the chisel at all times as nearly as possible parallel with the axis of the nerve.

Once the bony wound has been roughly chiselled out to the satisfaction of the operator, the cavity should be cleansed of bone chips, dust, and other *débris*. This may be done by forceps and cotton-tips, but is more thoroughly accomplished by the syringe. So that no drop of water pass down the Eustachian tube during syringing, the upper opening of this tube should be closed by a firm well-made cotton-tip, which is easily pushed into the tube and held there till syringing is finished. If oozing of blood be great from the deeper part of the wound, a solution of peroxide of hydrogen may be poured into the wound. When this is mopped out, a good view of the dry middle ear is obtained.

Examination by mirror and speculum before the operation, has taught the operator what he may expect on opening the middle ear—whether the malleus is present, and whether the incus has been already exfoliated. During the breaking away of the " bridge " or deeper part of the posterior wall of the bony meatus, or during the removal of the outer wall of the attic, the incus is likely to have been disturbed and already removed by forceps. If such has not been done, the incus if present should now be sought for and

removed, and the malleus similarly dealt with. With a strong beam of light reflected into the wound by a forehead mirror, and with a fine pair of [illegible] or sinus forceps, the removal of these two bones is not difficult. The incus may have to be disarticulated from the stapes, but unless the case be one of labyrinthine suppuration, the stapes should not be disturbed. This bone lies well sunk in its pit—the foramen ovale—almost under the plane of the inner tympanic wall.

After the middle ear has been emptied of its two greater ossicles attention must be paid to the walls of the tympanum. A bent probe must be run carefully along the roof (tegmen tympani et antri) in search of any diseased bone. The same must be done in the tympanic cellar. These two regions must be gently curetted with small sharp spoons, and the spoon must be made to enter the upper end of the Eustachian tube, so that all diseased tissue be removed, and cicatricial closure of the upper end of the tube produced. But the sharp spoon must be used with great gentleness on the internal tympanic wall, in case the stapes be disturbed in its attachments to the edges of the foramen ovale, or its crura broken.

Attention should now be turned to the shape of the wound in the bone, and particularly to the communication between the purely mastoid portion of it, and the tympano-meatal part. This communication must be as wide as possible without injuring the facial nerve (*Stereogram XXV*). This width is best got by enlarging the bony wound along the linea temporalis (upper part of the bony wound), and by paring off bone in an upward and inward direction along the ridge of the facial spur. This must be done with great care in case the facial nerve be injured, and in the doing of it the electrically driven burr will be found of great service. These burrs, of various sizes, are also well used for polishing up the walls of the cavity and rendering them smooth. They should not be used within the tympanic cavity. The shaping of the deeper part of the bony wound to the satisfaction of the operator may also be effected by sharp spoons, or by the chisel and mallet with which the greater

part of the operation has been performed. Next to the removal of all diseased products, and particularly of all diseased bone, this proper shape of the bony wound is of greatest importance.

Management of the Soft Parts in the Mastoid Operation.—The retro-auricular opening may be left unstitched, a light sterilized gauze packing placed between its lips, and a strip of gauze tape put into the middle ear. A pad of absorbent cotton is then placed over the auricle and contiguous parts of the side of the head, and the whole fastened by several turns of bandage tightly wound equator-wise round the forehead and behind the occipital protuberance, the ear of the other side not being included in the bandage. Several turns of bandage are then run lightly round the head at right angles to the first turns—round the vertex and under the chin. This method of dressing is suitable for those cases of mastoiditis in which an abscess in the mastoid cells has been opened, but in which the radical operation has not been done. It is, further, the best method in those cases in which intra-cranial complications are feared, and in those cases where the condition is such that healing by immediate union would not follow the stitching of the wound.

But if the radical operation has been done, the soft parts demand special treatment. A large wound has been made in the bone, behind the ear, the bony posterior meatal wall has been removed, but unless something more be done, the cartilaginous posterior meatal wall would remain a partition between the mastoid wound and the external auditory canal. If, however, the soft parts be slit along the posterior meatal wall, from the middle ear into the concha, if now these soft parts be papered against the widened wound in the bone, all dressing may be carried on through the external auditory canal, and the mastoid wound may be stitched up at the time of the operation, or treated by packing, as the operator should deem fit. These are the lines on which most modern aural surgeons proceed after the radical mastoid operation, but the splitting of the soft parts and the arrangement of the resulting flaps, is not always carried out after one fashion. The chief variations

in method are here given, but it cannot be too clearly understood that if all diseased tissue be removed, and the bony wound be given the proper shape, the particular method of cutting and arranging the flaps is of secondary importance, so long as free and permanent entrance through the external auditory canal be obtained.

1. *Panse's Method* (*see Fig.* 52).—The posterior wall of the cartilaginous canal is split along its middle from its inner end to the concha. From the outer extremity of this incision two smaller cuts are made at right angles to the first, so that a T-shaped wound is made, and an upper and a lower flap formed, which can be laid

Fig. 52.—Panse's Method.

Fig. 53.—Körner's Method.

Fig. 54.—Stacke's Flap.

against the enlarged wound in the bone. The flaps may either be kept against the bone by the packing used in the dressing of the ear, or additional security for their union may be got by attaching the flaps to the occipital aspect of the wound behind the auricle.

2. *Körner's Method* (*see Fig.* 53).—Two parallel incisions are made, one along the upper, the other along the lower border of the posterior meatal wall, and these are brought into the cavity of the concha. A tongue-shaped flap is thus formed, attached at its outer end, but free throughout its whole length, and this can be laid against the wall of the enlarged bony cavity. This may

be pressed against the bony wall behind by the packing which is to be introduced at the dressing, or following Politzer's practice, a split rubber drainage tube may be passed into the enlarged meatus and the packing applied through this tube, the whole or unsplit side of which presses the flap against the bone.

3. *Stacke's Flap* (*see Fig.* 54).—An incision is made along the upper border of the cartilaginous canal and brought into the cavity of the concha, and from the outer end of this a second incision is dropped at right angles to the first. This leaves a lower flap, which can be pushed downwards and thus be made to line the bony cavity.

The posterior surface of all of these flaps should be thinned, by removal of all cartilage and other tissue by means of curved scissors, so that close application to the bone is made easy. The wound behind the ear, the mastoid incision, must now be closely stitched, because all subsequent treatment is to be conducted by the widened meatus. A small gauze drain may, if the operator choose, be left at its lower angle, but this is not necessary. Five or six stitches are sufficient to close the wound accurately.

The packing of the wound cavity, whereby the split meatus is the more accurately applied to the bony wall, may be effected either by gauze tape or by pellets of sterilized gauze. The latter are packed closely into the wound cavity, and may be used plain, or they may be previously dusted with an antiseptic powder like iodoform or aristol. Pads of plain or iodoform gauze are now laid behind the auricle, a larger one is laid over the auricle, and a large flat piece of cotton- or wood-wool dressing is applied and kept in position by a bandage, as already described in speaking of the operation for opening an abscess within the mastoid cells.

The growth of skin over the newly-formed and enlarged bony cavity proceeds from the anterior wall of the meatus, and from the sides of the split posterior meatal wall. The first dressing should if possible be deferred for five to seven days, and the gauze packing or pellets should be removed as carefully as possible, so as not to detach the flaps from the bony walls. The writer is in the habit—unless there be very copious or fetid discharge—of carrying out the

dressing without syringing. The cavity is simply dried and re-packed. Exuberant granulations, when they occur, are either pressed down by the packing or snared by the wire loop. Healing takes place in the best cases in five to seven weeks, in the average case in two to three months, and in protracted cases, whenever the cario-necrotic processes which so often cause delay in the ultimate stages of these cases have come to an end. The management of these delayed cases will be noticed shortly.

The management of the radical mastoid operation as above described, assumes that no good reason exists for keeping the retro-auricular wound open ; but in practice it is not always wise to stitch the wound at the time of the operation. The indications for leaving the wound open and conducting the dressing from the mastoid wound for a longer or shorter period, are as follows :—

1. Great swelling and thickening of the soft parts over the mastoid process.

2. Similar swelling and inflammation of the soft parts over the temporal and zygomatic regions, in which pus collections may yet form.

3. The suspicion that intra-cranial complications have already begun and that, in spite of the radical mastoid operation, further operative interference may be necessary.

4. The existence of cholesteatomatous changes within the mastoid process, which cannot be thoroughly dealt with at the time of the radical operation.

5. The presence of sequestra within the mastoid process which cannot be safely removed at the time of the operation.

The advantages of the immediate closure of the retro-auricular wound are great. In a week or ten days the stitches can be removed from the soft parts, and in less than a fortnight all ear-dressings can be removed from the side of the head. The patient may thus resume business at a much earlier date than if packing be carried out through the mastoid wound. In most cases the widened external auditory canal is sufficient to give a view of every part of the granulating cavity, and every part of it can be packed or other-

wise dressed with precision. Then the scar on the mastoid process is so slight as to be practically invisible. Only a white line is left, without pit or depression, and this is placed so near the auricle that it is discovered only on the most critical examination.

Packing with gauze strips should not be carried out too long, else exuberant granulations will form. After the first two or three dressings it is enough to dry out the granulating cavity with cotton-tips, and plug the outer end of the external auditory canal with a pellet of cotton-wool.

Skin Grafting.—At various times surgeons have tried to shorten the period of healing after the mastoid operation by skin grafting the walls of the antro-tympanic cavity. Indeed, before the radical mastoid operation was performed at all, skin grafts had been successfully grown within the middle ear. For the healing of the recently enlarged antro-tympanic cavity the method of Siebenmann as developed by Ballance is successful.

Its details are briefly as follows. The radical operation is conducted on the lines above described, except that, in forming the flap, the incision along the external meatus is carried along the lower border of the posterior wall till the knife arrive at the concha, when the cut is made to sweep round within the concha in a curved direction upwards and backwards to the crus helicis. From the back part of this flap redundant tissue is removed, and it is fixed to the anterior flap of the mastoid wound by one or two stitches. Packing of the wound cavity is then carried out from the external auditory canal, and the mastoid wound is closed.

In ten to fourteen days the mastoid wound is re-opened, all exuberant granulations carefully removed from the wound cavity, and a large epidermal graft about an inch long and almost an inch broad is shaved from the inside of the upper arm or the thigh, and made to line the prepared antro-tympanic cavity. The handling of this graft is made easier by the use of a large section-lifter, with which the graft is floated on to the mastoid wound. By suction with a fine pipette, the underlying fluid is removed from below the graft, and its cut surface falls against the granulating bony cavity.

Against this the graft is packed with steel stoppers, so that it lies very closely against the irregularities of the bone. To protect the graft the cavity is next lined with thin gold foil, $\frac{1}{20000}$ of an inch in thickness. This is similarly closely applied to the epidermal surface of the graft, and all moisture removed as thoroughly as possible. Tamponing is then applied to the external auditory canal, the post-auricular wound is closed by stitches, and all subsequent dressings are done through the widened canal. Rapid lining of the antrc-tympanic cavity by skin takes place, and if all diseased tissue have been removed at the primary operation, complete healing of the cavity takes place in a few weeks. During the grafting operation nothing but sterilized salt solution is used for washing the wound and floating the graft.

More recently, Mr. Ballance has modified his operation in various particulars. The chief of these modifications are :—

1. The main mastoid cavity is not now grafted ; the graft is only allowed to cover the inner wall of the tympano-attic-antral cavity.

2. Gold leaf is discarded as a protection to the grafts, which are kept in position by tiny mops of sterilized cotton covered with gauze.

3. A new third stage of the operation is added, which consists in the deliberate removal of the dead portion of the graft. This is best and most accurately done under an anæsthetic, but may be done by the meatus without an anæsthetic.

The advantages claimed for Ballance's method of healing the tympanic cavity are, the more rapid epidermization of the antro-tympanic cavity, and the less liability of the healed tissue to break down under unfavourable influences. Its disadvantages are the repeated opening up of the mastoid wound, and the consequent necessity to wear a head-dressing of some sort for a longer period ; the repeated anæsthetizing of the patient for the operation of grafting, and for the removal of the dead portions of the graft. Like all mastoid operations in which a rapid and permanent result is to follow, Ballance's requires the thorough and complete removal of

all diseased bone, and the proper shaping of the bony wound. Now if these two conditions be complied with, a rapid result will be got without grafting. Even large operation cavities in the mastoid process heal rapidly and well, and delay is far oftener due to the presence of small cario-necrotic areas in the inner tympanic wall, which cannot be safely removed without damage to hearing. Grafting will not heal these cases. The writer for a time grafted most of his cases, especially those in which it had been necessary to make a large wound in the bone. The longer he operates the less does he fear such a large wound. These wounds, however large, will heal within a reasonable time—six to eight weeks—if the shaping of the cavity have been properly managed, and if the flaps have been so arranged that drainage is good, and easy access is got from the external auditory canal.

The Stacke Operation.—In 1892, Stacke proposed to reach the mastoid antrum, and to remove the products of inflammation from this cavity and from the tympanic attic, by chiselling the inner end of the postero-superior meatal wall, and thus reaching the antrum through the aditus. This reverses the procedure in the ordinary radical mastoid operation, by which the antrum is first found, and the attic reached through the aditus.

The early stages of the Stacke operation, by which the soft parts are divided, are similar to those already described in dealing with the radical operation. The remains of membrane and the malleus are removed, if these be present. The beak of the guide devised by Stacke is now introduced into the tympanic attic, and upon it the external attic wall is removed, till the tegmen tympani and the superior meatal wall pass uninterruptedly one into the other. The incus is now sought for, and the beak of the protector is made to occupy the aditus itself. Upon it the chisel removes the inner end of the postero-superior meatal wall, till the antrum is reached. The antrum, the attic, and the middle ear proper, are thus laid into one cavity, the walls of which can be smoothed and made to slope away towards the lower part of the external auditory

canal. The splitting of the posterior cartilaginous meatus is then conducted as in the ordinary radical operation.

It is unnecessary here to repeat the details which have already been given in this connection; rather is it important to indicate the special features of Stacke's operation, and the cases to which it is applicable. The guide protects the facial nerve and the external semicircular canal when its beak is in the attic, and the facial nerve at its bend and in the beginning of its descending part, when the beak is in the aditus. The guide, or a bent probe which may be made to take its place, should be used throughout, until the attic and antrum have been freely exposed.

As a method of removing the ossicles, Stacke's operation is thorough, and has the great advantage of removing the postero-superior pole of the tympanic ring, which is so often diseased in cases in which the ossicles are necrosed. It also exposes to view the tegmen tympani, and enables the surgeon to deal safely and thoroughly with disease there. But as a means of throwing open all the accessory cavities of the tympanum, Stacke's operation is insufficient, and unless disease of the mastoid cells other than the mastoid antrum can be excluded, the ordinary radical operation should be preferred. For disease limited to ossicles, Stacke's operation is too radical; for disease involving all the accessory cavities of the temporal bone, and especially the mastoid cells, it is not radical enough. Still, there are many cases in which disease exists beyond the ossicles themselves, in the attic and towards or even in the antrum, and to which Stacke's operation may be properly applied.

In deciding the question as to which must be done—the radical mastoid or Stacke's operation—two factors will weigh with the surgeon: his opinion in a given case regarding the extent of the disease, and his familiarity with one or the other procedure. The writer, where he has any doubt as to the state of the mastoid antrum and cells, always does the radical operation, and is not deterred from doing this thoroughly by the fear of protracted healing of a large bony cavity, for he is convinced that if this cavity be

properly shaped, and the after treatment properly ordered, healing of the mastoid wound will not be long delayed.

Delayed Healing after the Mastoid Operation.—Operators are constantly being asked for, and in many cases supply statistics of the results of the radical mastoid operation. How many cases heal within a short time, say two or three months? How many go on discharging for many months? How many cases do not heal at all? The answers to such questions do not seem to the present writer to be of great value, unless the conditions under which the operation is done are very carefully stated, and unless the reasons for delayed healing or for non-healing are given. It would seem more profitable to ask: Why does not every case heal well, and what are the exact causes of non-healing or delayed healing?

Before answering these questions, it is necessary to define exactly the cases in which rapid and final healing may be expected, if the technique of the operation be successfully carried out. The tubercular affections of the temporal bone must be excluded from this discussion, because, especially in the case of young children, it may neither be possible nor safe to remove all the diseased bone, and because the constitutional diathesis may make the bone disease advance even after a thorough operation. But if these be excluded, fairly definite answers may be given to the two questions put. The operation under discussion is the radical mastoid operation, in which, in addition to the opening of the bony cavities, the posterior cartilaginous wall has been split, the post-auricular wound stitched, and the subsequent dressings carried on through the external auditory canal.

The commonest cause of protracted healing in the upper part of the wound—towards the middle fossa of the skull and the sigmoid sinus—is undoubtedly *improper shaping* of the bony wound. From a very wholesome and necessary fear of wounding the facial nerve, the part of the posterior meatal wall which is removed is too small, and the communication between the meatus and the ablated mastoid antrum is too narrow. This communication becomes choked with exuberant granulations, retention of discharge within the mastoid

portion of the wound takes place, and healing ceases. This cause of delayed healing can be avoided. If the bony wound be made wide at its superficial part, if the posterior meatal wall be removed widely in its superficial part, and not too widely in its deeper part, free access will remain to all the parts of the mastoid process, and during the operation the facial nerve is not likely to be injured. It matters little whether it has been necessary to remove the tegmer tympani or not, whether the sigmoid sinus has been exposed or not—indeed it is better to expose these freely than leave carious bone—if all diseased tissue be removed and if the communication under discussion be wide, rapid healing will take place. In nearly all the writer's cases where these conditions have been complied with, healing of the vault of the wound and of its posterior limb towards the mastoid process takes place, often in six or eight weeks, and seldom does it take three months.

Within the tympanic cavity, and in the lower part of the wound, the causes of delayed healing are *small necrotic areas of bone*, and *re-infection* of the granulating middle ear from a patent Eustachian tube. Under the heading of necrotic areas must be included fistulæ into the internal ear—through the internal tympanic wall. Small necrotic areas often exist over the internal tympanic wall—promontory—and in the tympanic cellar, and the presence of these may be discovered by the operator only after the rest of the operation wound has healed; these patches remain obstinate. A good deal can be done by careful scraping of granulation tissue and exposed bone at the time of the operation, but if the operator have for his object the retention of the stapes and the retention of the residual hearing, his manipulation with the sharp spoon must be limited and carefully conducted. In otherwise healthy patients, the persistent dressing of these necrotic areas results in healing, although months may elapse before this result is attained. Granulation masses may have to be removed by the cutting forceps, or by snare or caustics.

Re-infection of the healing tympanum by way of the Eustachian

tube, may be prevented by so curetting the upper extremity of the tube as to cause cicatricial closure of its tympanic opening.

Amongst minor causes of delayed healing are the too long continued packing to its inner end of the external auditory canal with strips of gauze. This encourages the growth of exuberant granulation masses, which may have to be removed before further progress can be made. After the first week or ten days such packing should be discontinued, and the canal, which forms a natural drainage tube, cleared of discharge by passing small cotton-tips into every recess at its inner end. Some surgeons advise the instillation of spirit drops to lessen the discharge and hasten the healing, but the writer simply drys the canal, and with the object of keeping out water and dust, plugs its outer end with cotton-wool. Spirit drops sometimes increase the discharge and delay healing.

Risks of the Mastoid Operation.—With regard to life, the risks of the operation are very small. A few cases are recorded in which the mastoid operation seems to have lit up into activity to intra-labyrinthine disease of old standing, and in this way have spread infection to the cranial cavity. But if these cases be excluded, and if intra-cranial complications already established be excluded, the mastoid operation is not only a safe one, but is the safer the more thoroughly it is done. The channel by which infection reaches the brain in these cases of labyrinthine disease is probably the veins of the labyrinth which open into the lateral and inferior petrosal sinuses.

The minor risks of the operation are these : The opening of the middle fossa of the skull ; the wounding or exposure of the sigmoid sinus ; and the injury to the facial nerve. If the bent probe be carefully used in the aditus, the antrum will always be found, and the middle fossa will not be mistaken for it. After the antrum has been found, the bent probe will again define the limits of this cavity. If the dura in the middle fossa or the wall of the sigmoid sinus be exposed, no harm will result if the septic material within the mastoid process be thoroughly removed and the wound packed. Should the sinus be unintentionally opened—an accident

which happened twice to the writer in his earlier operations—it may be necessary to stop the operation for the time, but the vessel may be successfully plugged, and no complications will happen if the surroundings be clean.

The commonest accident during the mastoid operation is injury to the facial nerve. This experience must happen often to every thorough operator. The nerve is often already exposed in its horizontal part within the middle ear, and the writer has seen temporary paralysis follow such slight injury as was caused by a well guarded cotton-tipped probe, when the latter was used in finally cleaning out the middle ear after the mastoid operation. But permanent total paralysis scarcely ever results from injury to the nerve occurring during or after any of such operations. Sometimes the paralysis comes on one or more days after the operation, sometimes it lasts only a few days, oftener two or three weeks, occasionally several months; hardly ever is it permanent, although in the cases lasting over months the recovery of the nerve may not be quite complete. In the vertical part—from the aditus through the inner end of the lower half of the posterior meatal wall to the stylo-mastoid foramen—the nerve need never be injured. The posterior meatal wall must be removed in its whole depth down to the aditus in its upper half. But in its lower half the inner third must not be removed, as it contains the nerve, which must be injured if this part of the bone is attacked. Plenty of room can, however, be got for all the purposes of the operation, if the wound in the bone be made funnel-shaped, wide at the mouth and narrow towards its depth in the aditus.

With regard to *hearing*, it may be said that the radical mastoid operation, as a rule, does not damage, neither does it improve hearing. In most cases where it is performed, extensive destruction of membrane has taken place, the incus is often absent, or if present its articulation with the stapes is valueless in the conduction of sound, so that removal of the remaining membrane, and of the incus and malleus, does not further damage hearing. On the other hand, if the radical operation be performed in a case where the ossicular

connections are good and the hearing is good, the operation is quite likely to damage hearing. A mobile stapes, even if unsupported by the other ossicles or by tympanic membrane, will, if the labyrinth be intact, give good hearing after the radical operation.

Where the suppurative disease is unilateral, and the hearing in the other ear is perfect, the operator should do the radical operation thoroughly, irrespective of the probable effect on the hearing. Where the suppurative disease is bilateral, the writer has in several cases done the radical operation on the worse hearing ear, and the Schwartze, or partial operation, on the better hearing ear. In no case should the operator *promise* that hearing will not be damaged by the radical mastoid operation.

CHOLESTEATOMA.

During the progress of chronic suppuration within the middle ear, the epithelium in that cavity and the epidermis in the external auditory canal are stimulated to overgrowth, and deposits of cellular material mixed with pus and other *débris* form cheesy masses within the recesses of the temporal bone. When a perforation exists in the upper and posterior part of the tympanic membrane or in Shrapnell's membrane, the epidermis of the external auditory canal may pass over the edge of the perforation, especially if it be very peripheral in situation, make an inroad into the middle ear, and proceed to line, not only the latter cavity, but also the mastoid antrum or the tympanic attic, or both. Within these confined cavities the epidermic growth continues, layer after layer of cells becomes packed within the confined area, and the result is a definite *tumour* composed of concentrically arranged epidermic cells, purulent *débris*, micro-organisms, and cholesterine crystals.

The mucous membrane of the middle ear and mastoid antrum serves, as will be remembered, the purposes of a periosteal lining, so that the bone underlying the aberrant epidermic growth becomes involved in the diseased process. Further, the gradual increase of the tumour, which may range from the size of a pea to that of a walnut, causes absorption of the containing bony walls, and an

opening may be made in the bone either towards the sigmoid sinus, the middle fossa of the skull, the surface of the mastoid process, or through the upper or posterior wall of the external auditory canal, into the meatus. Carious disease of the bone may co-exist with the presence of these tumours, and as there are abundant micro-organisms always present, intra-cranial complications may at any time arise.

For an indefinite period there may be no symptoms ; but should swelling of the epithelial masses occur, pressure symptoms set in. This may be determined by the intentional or accidental entrance of water—as in syringing, or during sea-bathing. The consequence is headache, giddiness, and discomfort in the side of the head. Vomiting and febrile symptoms may also come on.

The DIAGNOSIS is not always easy. With a bent probe it may be possible to detach pieces of the tumour, or with a syringe to wash shreds away. If granulation masses co-exist, there is probably also caries of the bony walls. In the washings cholesterine crystals may be got and identified, either by their special shape under the microscope, or they may be discovered by applying the proper chemical test. Within the mastoid process the application of objective tests is not possible ; but from the attic and from the aditus it is often possible to get proof that these spaces are filled with cholesteatomatous material. Sometimes large openings are thus made by the disease, through which the surgeon, by probe or scraper, may remove at least part of the tumour.

Cholesteatomata are sometimes extruded spontaneously from the middle ear, or from the openings which have been made into the meatus by their own pressure ; but the usual result is that by their increase in size, and on account of the micro-organisms which are present, a mastoiditis or an intra-cranial complication sets in, and operation is rendered imperative.

TREATMENT.—An attempt should be made by the help of attic syringing to dislodge masses after their presence has been discovered. Suction by Siegle's speculum may do something in the same direction. Granulation masses should be removed by

scraper, and necrosed ossicles removed. But it should be remembered that syringing may cause the masses to swell, and precipitate the pressure symptoms, so that unless there is a good opening from the attic or aditus, and the danger of retention is very slight, syringing should be avoided. If a fistula exist in the posterior meatal wall, the tumour may be reached in this way. Relapses are apt to follow all such partial measures as the above, for the diseased lining membrane remains, and the tumour grows afresh. If the diagnosis be clear, or if threatening symptoms occur, the radical mastoid operation should be performed at once. No time should be lost in less heroic treatment. Often the mastoid cells have been so destroyed, and laid together, that little is left for the surgeon to do within the substance of the mastoid process. Often, too, the aditus ad antrum has been greatly widened, and the inner end of the posterior meatal wall in great part destroyed. Careful inspection should be made of the tympano-antral roof, and of the bony wall towards the sigmoid sinus, and if any cario-necrotic fenestræ be discovered, the disease must be followed into the cranial cavity. The walls of the bony cavity should be dealt with very radically, for the epidermic process in many cases penetrates the bone itself.

If any doubt exist as to the result of the operation, a retro-auricular fistula may be kept open, and only closed after months or years, when further relapse is not likely. If this be not done, the plastic operation must be of such a nature as to leave a very wide opening into the mastoid cells from the external auditory canal. Skin grafting in these cases is not desirable.

CARIES AND NECROSIS.

The intimate connection between the mucous membrane of the middle ear and the underlying bone, explains the readiness with which the ossicles, the bony tympanic walls, and the bone within the mastoid process become diseased when the mucous membrane is inflamed. This inflammation is most violent in the acute purulent otitis of measles, scarlet fever, etc., whilst in tubercular affections the nutrition of the bone is more profoundly affected. Hence

caries and necrosis of the underlying bone follow most readily, and are most extensive in these diseases, but they occur in places within the tympanum and in the ossicles, in all forms of middle-ear suppuration. In tubercular affections and in the acute infectious diseases, the disease of the bone is apt to spread deeply, and sequestra form in the mastoid process and in the middle ear, the sequestrum here often involving the bony labyrinth. In chronic middle-ear suppuration, the disease of the bone is more superficial, attacking the promontory, the ossicles, the tegmen tympani, the tympanic ring, and the hypo-tympanic recess or cellar of the tympanum. The facial canal is apt to be involved in the bone disease of tubercular affections, and facial paralysis follows. Retention of purulent contents is an important factor in the progress of these cases, and acute mastoiditis results. Generally the retained products burst outwards towards the external surface of the mastoid process; but infection often takes place inwards, either by venous channels or by erosion of the bony walls, and meningitis, abscess, or sinus thrombosis results. Recurring granulation masses within the middle ear indicate the location of the cario-necrotic bone, either in the tympanic attic or towards the mastoid antrum. When the rupture takes place into the meatus, a sinus is present on the postero-superior wall, and the probe passed into the sinus detects the diseased bone. The ossicles, when discharged or when removed by operation, show eroded parts. The incus is most commonly necrosed, the stapes least so; the latter because of its better and more direct blood supply (from the side of the labyrinth). Small areas of caries may be discovered on the ossicles (malleus and incus), the perforation being in that case either in Shrapnell's membrane (malleus) or in the postero-superior quadrant of the membrane (incus), and the probe passed through the perforation strikes the diseased ossicle.

In limited ossicular caries, the discharge may be very slight, and may dry as it exudes and form a crust. If the bone disease is extensive, the discharge is great and often fetid. It is sometimes bloody (granulation masses), and examination of the discharge

between the fingers may detect bone sand, and evidence of caries which may be confirmed by microscopic examination. If symptoms of mastoiditis follow, severe pain occurs, but in tubercular cases extensive disease may exist with scarcely any pain.

The TREATMENT is on the lines indicated in describing mastoiditis and middle-ear suppuration. The strictest antiseptic treatment must be followed; granulation masses must be curetted or snared; sequestra must be removed either by way of the external auditory meatus or by the sinus on the mastoid process. It is sometimes necessary to crush or break these bony masses before removal.

If retention signs and symptoms show themselves, the mastoid process must be freely opened up, and the whole of the disease removed as far as possible. Where the disease is limited to an ossicle or part of an ossicle, and where the discharge is slight and forms a crust, this latter must be removed, the ulcerating surface wiped clean, and then dusted with a dry powder like boracic acid or aristol. Thorough cleansing of the ear may be done from time to time by using an ear-bath of hydrogen peroxide. Should this fail, removal of the diseased ossicle must be effected. Much time and skill must be spent by the surgeon, and much patience displayed by the sufferer, in the management of these cases. The general health of the latter must be attended to.

CHAPTER IX.

Diseases of the Middle Ear, continued.

THE INTRA-CRANIAL COMPLICATIONS OF SUPPURATIVE MIDDLE-EAR DISEASE.

Intra-cranial Anatomy and Ear Disease—Topography of the side of the Skull—Paths of Infection or Pus Channels from the Ear to Intra-cranial and other Structures—The Pathology of Intra-cranial Complications—Simple and mixed Infections—Extra-dural Abscess—Sinus Thrombosis—Abscess within the Brain—Meningitis—Differential Diagnosis of the Various Intra-cranial Complications of Middle-Ear Disease—Operative Treatment of the Intra-cranial Complications of Middle-Ear Disease—Tying the Jugular Vein in the Neck—Illustrative Cases—Ear Disease and Life Insurance.

INTRA-CRANIAL ANATOMY AND EAR DISEASE.

THE dura mater may be looked on as the internal periosteum of the skull, intimately attached to the bone at the base, but loosely at the sides of the skull, except at the sutures and the foramina. The dura mater may pulsate synchronously with the arterial beat, and may rise and fall with respiration. The sinuses of the dura are contained between the endosteal and meningeal layers of the membrane, and are lined by a prolongation of the lining membrane of the veins with which they are connected. The lateral sinus is the largest of the intra-cranial vessels, and the right sinus is larger than the left. The connection with the heart of the right lateral sinus, by the jugular vein and the right innominate vein, is more direct than on the left. The lateral sinus receives also the superior petrosal sinus, which derives some of its blood from the tympanic cavity, the mastoid and posterior condyloid veins, veins from the diploe, and veins directly from the mastoid process. The jugular bulb receives the inferior petrosal sinus, and the vein of the aqueduct

of the cochlea; the vein of the aqueduct of the vestibule enters the lateral sinus.

The posterior sub-arachnoid space communicates with the perilymph of the ear by the aqueduct of the cochlea, and the perilymph also communicates with the sub-dural space by means of the sheath of the auditory nerve. Similarly, the posterior sub-arachnoid space communicates with the sub-arachnoid space of the spinal cord, and with the fourth ventricle of the brain by the foramen of Magendie on its roof, and by the foramina of Key and Retzius on its sides. These relationships are of importance in the consideration of the intra-cranial complications of suppurative disease of the middle and internal ears.

The parts of the brain contiguous to the organ of hearing, are the temporo-sphenoidal lobe of the cerebrum, and the cerebellum. The upper surface of the petrous portion of the temporal bone supports the temporo-sphenoidal lobe, the tegmen tympani forming a very thin plate between the brain and the middle ear. The posterior surface of the petrous portion is in contact with the sigmoid sinus and with the cerebellum.

The auditory nerve has been described as having six endings in the ear, but these may be grouped into two; a cochlear portion, going to the cochlea, and a vestibular, supplying the vestibule and semicircular canals. Both of these divisions arise from nuclei in the medulla oblongata. The nuclei are three in number, *viz.*, Deiter's, the accessory, and the chief nucleus. The two roots rise on either side of the restiform body of the medulla, the lateral root chiefly from the accessory nucleus, and the mesial root from Deiter's nucleus and the chief nucleus. The lateral is continued as the cochlear nerve, and is the special nerve of hearing; the mesial root is continued as the vestibular portion of the auditory nerve, and supplies the vestibule and semicircular canals; the vestibular nerve is the nerve of equilibration. Beyond the medulla, the cochlear portion is said to be traceable to the corpora quadrigemina by way of the fillet, and from the corpora to the posterior part of the inner capsule by way of the geniculate body, whence they reach the

cortical cells of the superior and middle convolutions of the temporal lobe. The chief course of the vestibular portion from the medulla inwards, is to the crus cerebelli and vermiform process of the cerebellum.

Topography of the Side of the Skull.—When discussing the mastoid operation, the landmarks on the surface of the temporal bone which guide the surgeon in performing the radical operation were indicated, *viz.*, the linea temporalis, Henle's spine with the supra-spinous process, and the tip of the mastoid process. But in dealing with the intra-cranial complications of middle-ear disease, it is often necessary to enter the cavities which under ordinary circumstances we must avoid, and for this purpose additional land-marks are available.

If a line be drawn on the side of the skull from the lower margin of the orbit, along the line of the zygoma, through the middle of the external auditory meatus, it will cross the mastoid process a little below the level of the antrum. Continuing this line backwards, it will cross the sigmoid sinus about the knee of the latter, pass just above the mastoid foramen on to the occipital bone, and for a distance of nearly two inches will run on this bone clean below the transverse part of the lateral sinus, after which it again crosses the lateral sinus. This is **Reid's Base Line** (*see Fig.* 55), and forms the guide for the opening of the cerebellar fossa. When that fossa has to be independently opened for suspected abscess, the opening should be made about an inch and a half behind the centre of the meatus, and a quarter of an inch below Reid's base line. When it is necessary to explore the cerebral fossa, and to open it independently of a previous operation-wound, this should be done through the squamous portion of the temporal bone above the linea temporalis, which may itself be taken as the guide to the lower limits of the temporo-sphenoidal fossa; or the centre pin of the trephine may be made to enter the bone about an inch above Reid's base line on a perpendicular through the posterior margin of the meatus (*see Fig.* 55).

When studying the anatomy of the temporal bone, the principal

anatomical **Channels of Infection** from the middle ear to surrounding structures were named (*pp*. 26 and 27). But the commonest paths of infection, perhaps, are those which are created by the long continuance of cario-necrotic processes in parts of the temporal bone contiguous to the brain. The tegmen tympani et antri and the sinus-mastoid wall are thus attacked, and channels of infection are thus opened up to the middle fossa of the skull on the one hand,

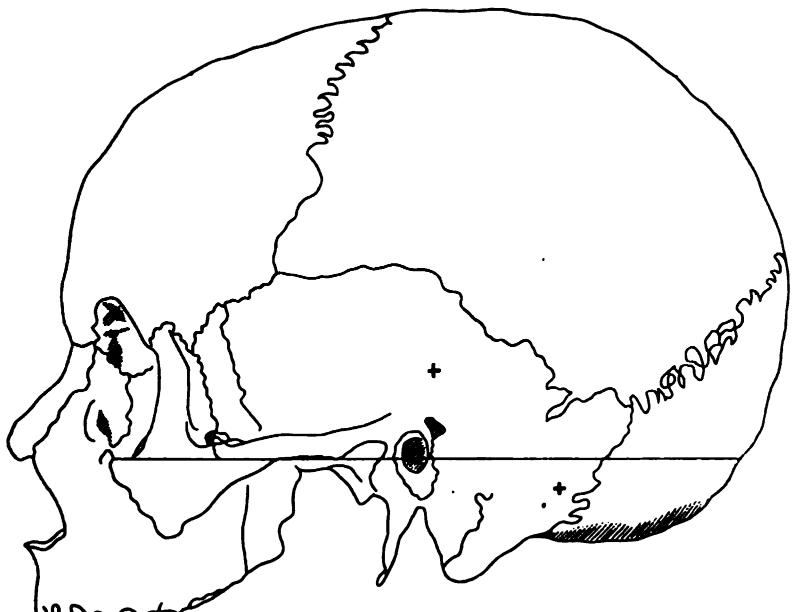

Fig. 55.—Reid's Base Line. The marks + + show the points where the skull should be opened for cerebral and cerebellar Abscess.

and to the sigmoid sinus and cerebellum on the other. In the latter situation there is direct venous communication between the mastoid cells and the sigmoid sinus, and these veins have no valves. In the lower part of the tympanum, cario-necrotic processes may pass backwards towards the jugular bulb, which is sometimes placed so high up as to encroach on the tympanic cavity, and here the bony wall may be defective. In the front of this lower part of the tympanum, cario-necrotic processes may cause infection of the

structures round the carotid artery, and erosion of the walls of the vessel itself.

The same changes may take place within the internal ear. Erosion of the promontory is a common occurrence in chronic middle-ear suppuration, infection may attack the internal ear, and through it the intra-cranial structures. The internal auditory meatus and the aqueducts thus become channels of infection, and the cario-necrotic erosion may reach the middle fossa by the side or through the roof of the superior semicircular canal (*eminentia arcuata*). There the wall of the bone between the dura of the middle fossa of the skull and the lumen of the semicircular canal is never very thick.

There can hardly be any doubt that the commonest channels by which pus reaches the intra-cranial structures are these :—

1. Cario-necrotic openings between the middle ear and mastoid process on the one hand, and the middle and posterior fossæ of the skull on the other.

2. Infection of the posterior fossa along the sheaths of the facial and auditory nerves, from purulent foci in the internal ear and tympanic cavity.

3. Direct contamination through venous channels, such as pass from the mastoid cells to the sigmoid sinus.

PATHOLOGY OF INTRA-CRANIAL COMPLICATIONS.

Intra-cranial infection may take the form of *abscess*, *meningitis*, or *sinus thrombosis*. Clinically, it is very important to separate these, but often it is not possible. It is convenient, therefore, to consider intra-cranial complications in the first place as a whole; an attempt being made afterwards to differentiate between their various forms. When an ear case goes wrong, or when for the first time the surgeon sees a case of middle-ear suppuration in which intra-cranial complications threaten or have become established, the signs and symptoms have to be considered in the light of what is known of the morbid anatomy of the conditions possibly or probably present.

Intra-cranial complications follow chiefly upon middle-ear suppuration of old standing. Purulent collections in the attic or within the mastoid process cause erosion of the bony wall, and the dura is exposed to the action of pathogenic micro-organisms. Thickening of the dura follows, granulation masses spring up near the opening in the bone, and may project to the inside of the cranial cavity, and also downwards so as to be seen at the roof of the middle ear through the external auditory canal. An extra-dural collection of pus may thus form over the tympanic tegmen, or a perisinus abscess may form by disease of the sinus-mastoid wall, next the posterior mastoid cells. Such extra-dural abscesses may consist of but small collections of pus, which may drain through the bony opening with more or less thoroughness. In a case of the writer's, although the bony erosion was distinct, and the granulation bud projected well into the middle fossa and leant against the dura, the amount of pus was very small. On the other hand, the collection of pus may amount to several ounces.

But the irritation and infection may pass through the dura, the upper surface of which becomes thickened; the arachnoid membrane in its turn becomes affected, and adheres to the inner surface of the dura, and to the outer surface of the pia mater. This adhesion of the surfaces is a conservative process. According to its situation and thoroughness, it may result in a collection of pus between the arachnoid membrane and the dura mater—a sub-dural abscess; or a limited lepto-meningitis, bounded by the edges of adherent arachnoid and pia mater, may take place. In the absence of any limiting adhesion, a general lepto-meningitis may take place. Further, in spite of adhesion of the meningeal structures, absorption into the interior of the brain may occur, and a *brain abscess*, temporo-sphenoidal or cerebellar, may develop. Such a collection of pus may be connected with the fistula in the bone through which infection has entered, or may be separated from the fistula by sound brain tissue, but it is usually near the diseased bone, and therefore usually near the tegmen tympani or the sinus-mastoid wall. Once the dura is opened and the meninges become attacked, the adhesive

processes which limit the disease act with much less certainty than they do outside the dura. In the latter situation the sutures of the skull often determine the extent of the purulent area; in the former, a general lepto-meningitis, spreading downwards to the base of the brain and upwards over the vault, is common.

When the processes above described occur near one of the great sinuses, the sinus itself becomes involved. Granulation masses invade the sinus wall, cause it to thicken, and soon infection reaches its inner lining. A thrombus forms round the invaded wall, and ultimately blocks the vessel more or less completely. The thrombus is infective in its nature, or soon becomes so; this breaks down, infective material is swept into the systemic circulation from the partially blocked vein or from the lower end of a softening thrombus, and pyæmia results. Lung affections follow, and metastatic manifestations may occur in various parts of the body.

These conditions may occur together, and a mixed infection may result. In a case of the author's, a meningitis, a sinus thrombosis, and a cerebellar abscess all occurred together.

SYMPTOMS.—In **Extra-dural Collections of Pus** there may be no symptoms, or there may be pressure symptoms. There is generally headache, either local or diffuse, and the pain is worse at night. The pulse-rate, except in the earlier stages, is low: 60, 50, or even 40 per minute, according to the amount of pressure; and the temperature is sub-normal. If the collection be in the cerebellar fossa, stiffening of the muscles of the neck may be present. Sickness and vomiting may occur, and general dullness or stupor may follow. If there be meningitis, the symptoms of abscess pressure are masked by the more general and less defined symptoms of the meningitis. **Meningitis** has symptoms of more general irritation. There is photophobia, sleeplessness, tossing about of the patient in bed, and delirium. Vomiting is often present. The pupils are contracted and their reaction to light lessened. There may be rigidity of the muscles of the neck, convulsions, and twitching of muscles. Later the symptoms become more marked. The patient may become maniacal; optic neuritis is often present,

sometimes absent; the pupils are unequal and dilated; ptosis is sometimes present, and squinting may also occur. Towards the end, paralysis of the bladder and rectum supervene, and the patient becomes comatose, death occurring sometimes suddenly, or after periods of apparent improvement. The breathing, especially during the later stages of the case, is of the Cheyne-Stokes variety. The temperature is variable; usually it is moderately high, but may be sub-normal; the pulse is quick and full at first, but becomes very feeble and rapid towards the end.

When **Sinus Thrombosis** exists, the temperature is much more characteristic than in meningitis (*see Case* 9). Severe rigors occur, sometimes daily, sometimes at intervals of days. The temperature runs up to 103°, 104°, or even 105°. Sudden fall brings copious perspiration, and the temperature may reach the normal or become sub-normal. Oscillations of this kind carried over a series of days, with rigors and sweatings, are almost diagnostic of sinus thrombosis. Apart from the peculiar temperature and pulse, the symptoms may simulate those of meningitis. There may be headache, vomiting, and optic neuritis. A search should be made on the side of the head and down the neck, for signs of venous obstruction. If the mastoid vein be obstructed, œdema of the mastoid process may be present. If the thrombosis extend to the jugular vein in the neck, it may be felt as a cord by the examining finger. If there be thrombosis of the facial vein, the side of the face may be œdematous. As between meningitis and sinus thrombosis, the diagnosis is not always clear; but lumbar puncture may be tried, and the cerebro-spinal fluid examined for micro-organisms. If the fluid be clear, and no micro-organisms be discovered, thrombosis may be suspected. It is in sinus thrombosis, of course, that metastasis is most common. Thus symptoms may occur in the lung, or in the joints, muscles, and internal organs like the liver and kidney. A symptom which may be of some value in sinus thrombosis is pain on pressure over the posterior border of the mastoid process. Such pain over the mastoid process itself, has been noticed when considering mastoiditis.

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DIFFERENTIAL DIAGNOSIS IN THE INTRA-CRANIAL COMPLICATIONS OF SUPPURATIVE MIDDLE-EAR DISEASE.

Symptom or Sign.	Brain Abscess.	Meningitis.	Sinus Thrombosis.
DISCHARGE	Present, but may be temporarily lessened	Present, but may be temporarily lessened	Present, but may be temporarily lessened
TEMPERATURE	Sub-normal or only slightly raised	High, without marked remissions	High, with marked and often repeated falls, profuse perspiration, rigors common
PULSE	Slow	Moderately fast, or very rapid, seldom slow	Fast, or even very rapid
HEADACHE	Often present	Common, and either diffuse or localized	Not common in uncomplicated cases
EYE SIGNS AND SYMPTOMS	Retinitis or choked disc may be present, contracted and often unequal pupils	Retinitis or choked disc common, pupils contracted or dilated. Strabismus	Retinitis or choked disc often present
VOMITING	Sometimes present	Common	Not common
RESPIRATION	Normal or slow, and may be of Cheyne-Stokes' variety	Cheyne-Stokes' variety present	Rapid, or of the Cheyne-Stokes' variety
SIGNS AND SYMPTOMS IN THE NECK	Absent	Absent, or rigidity of the neck muscles	Sometimes tenderness, and a hard cord felt by the finger
GENERAL CONDITION	Dullness of intellect, sometimes unsteadiness of gait, and giddiness	General irritability, at first delirium, and later, coma	Great depression, and asthenia, if systemic infection be in progress, secondary infection of lungs and other metastatic phenomena.

In cerebellar cases there is vertigo, staggering gait, and rigidity of the muscles of the neck.

All intra-cranial complications tend to follow old-standing, as against recent middle-ear suppuration. In all, the middle-ear discharge may be so slight that the patient thinks it does not exist. The discharge, although slight, can almost always be found by a cotton-tipped probe, and has often a bad odour.

Unfortunately, intra-cranial complications are often of the mixed type, sinus thrombosis and cerebellar abscess co-existing, whilst meningitis may be added to these. Cases are therefore not always typical, and diagnosis is often very difficult. The symptoms and signs belonging to one condition mask or hide those belonging to another, so that during operation or *post-mortem*, it is quite common to find conditions present which have not been suspected at the pre-operation study of the case. But it will often be the duty of the surgeon to interfere, though no definite localizing symptoms have appeared. Whether he interfere, or wait for localizing signs and symptoms, will depend on the condition of the patient and on the acuteness of the case. But if the symptoms are well defined, and when meningitis can be excluded, the surgeon should not be deterred from operation by the apparent gravity or even hopelessness of the case.

THE PROGNOSIS in the intra-cranial complications of suppurative middle-ear disease is very bad without operation, but good with operation in those cases in which a generalized meningitis has not occurred.

OPERATIVE TREATMENT OF INTRA-CRANIAL COMPLICATIONS.

Assuming that the symptoms and signs are definite enough for the diagnosis of the particular intra-cranial complication which has arisen in the course of a middle-ear suppuration, the surgeon may choose to enter the middle or posterior fossa of the skull, without previously laying bare the original focus in the middle ear and its connections in the mastoid cells. Such a procedure would be justifiable in a case in which urgent symptoms demanded immediate interference, in which the localizing signs and symptoms were very

dura mater being exposed. The radical operation was done, the canal split, and the mastoid wound stitched. It was twice dressed before December 26th, when grafting was done. Dismissed from "Home" on January 10th, with the whole tympano-antral cavity skinned except at one small point, at the junction of the graft and the upper meatal flap.

Result.—Complete healing of middle ear. Hearing for whispered speech good.

CASE 3, A. C.—*Obstinate otorrhœa. Mastoid tenderness, erosion of the sinus mastoid wall. Perisinus (extra-dural) collection of pus. Operation. Recovery.*

Case brought to the writer with mastoid tenderness on Dec. 12th, 1903. There was a very small quantity of discharge from a tiny perforation in Shrapnell's membrane. The radical mastoid operation was performed on Dec. 15th. The process was found filled with a large cheesy mass, the sinus-mastoid wall was eroded, and round the sinus a large quantity of cheesy pus was found. There was no reason to suspect infection of the sinus, for the temperature was normal. The sinus was laid bare for an inch of its length, the post-auricular wound was stitched, and the further treatment carried out through the external auditory canal.

Result.—The wound healed in five or six weeks, and the case continues without discharge or symptom of any kind. Grafting was not done.

CASE 4, D. G., *æt.* 12.—*Old-standing otorrhœa. Cerebellar abscess. Operation. Recovery from abscess. Occurrence of hernia cerebelli. Death at later date from an unknown cause.*

Admitted to the Royal Infirmary on March 6th, 1900, with an abscess behind the left ear, and a temperature of 100°, which on the 7th rose to 102°. On March 9th, a Wilde's incision was made down to the bone through the greatly-thickened tissues, and a large quantity of pus evacuated. A large polypoid mass existed in the meatus. The history of the case is one of discharge of a year's duration, and of mastoid pain and swelling of the post-auricular soft parts, of nearly two months' duration, with recently a tendency to be apathetic and to talk less than usual. During the first days in the hospital, he was dull and irresponsive, slept a great deal, face was immobile, but without paralysis, pupils large and equal. The legs were weak, and he could not stand, and could only sit for a few seconds without support. Knee-jerks absent. He complained little of headache, and vomited only on one or two occasions.

After the incision of the soft parts on the 7th, the temperature fell, but oscillated a little, and on the 16th the mastoid cells were freely opened and the granulation masses removed from the canal; but the radical operation was not completed, for the soft parts were still so much thickened that it was difficult to work accurately in the deepest parts of the temporal bone. This operation on the bone was followed by a fall of temperature to the normal, and on March

between the two. The vein should be picked up by an aneurysm needle, care being taken not to injure its walls or to include the nerve in the ligature. The ligatures should be applied at two places, and the vessel cut between.

Within recent years, the practice has been established of dealing even more radically with the jugular vein—by dissecting the cut vein upwards as far as possible towards the jugular bulb, ligaturing its branches, and removing as much of the vessel as possible.

It is not an uncommon experience in operating for symptoms pointing to an intra-cranial complication, to open the middle fossa of the skull and cerebellar fossa, and to find no pus, nor any sinus thrombosis. Such a procedure, although unsatisfactory from the operator's point of view, is not attended by much danger to the patient. If aseptic precautions have been observed, and if any discs of bone which have been removed be carefully replaced, little disturbance occurs, and in some cases the loss of cerebro-spinal fluid which follows opening of the dura mater, seems to give relief to the patient, and even to cause permanent improvement.

CASES ILLUSTRATING INTRA-CRANIAL COMPLICATIONS OF MIDDLE-EAR SUPPURATION.

The following cases have been chosen with the object of illustrating the nature of the morbid changes within the cranium which follow middle-ear suppuration. In order to do this fairly, it has been necessary to choose unsuccessful as well as successful cases: indeed, the former best illustrate the subject in hand.

CASE 2, B. C., *æt.* 13.—*Obstinate otorrhœa, erosion of tegmen tympani, and exposure of dura mater. Operation. Recovery.*

At seven years of age measles occurred. During the attack the nasal symptoms were bad, and there was pain in the ear, but definite discharge going on continuously dates from six months ago, June, 1901. In October, 1901, she came with polypi in the left ear. After removal of these the discharge almost ceased, but the granulation masses began to sprout from a point on the roof of the middle ear, where the probe easily detected bare bone.

Operation (Dec. 14th, 1901).—The tegmen tympani was found eroded and perforated, the upper end of the granulation mass projecting through it, and the

dura mater being exposed. The radical operation was done, the canal split, and the mastoid wound stitched. It was twice dressed before December 26th, when grafting was done. Dismissed from "Home" on January 10th, with the whole tympano-antral cavity skinned except at one small point, at the junction of the graft and the upper meatal flap.

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The following cases have been chosen with the object of illustrating the nature of the morbid changes within the cranium which follow middle-ear suppuration. In order to do this fairly, it has been necessary to choose unsuccessful as well as successful cases: indeed, the former best illustrate the subject in hand.

CASE 2, B. C., *æt.* 13.—*Obstinate otorrhœa, erosion of tegmen tympani, and exposure of dura mater. Operation. Recovery.*

At seven years of age measles occurred. During the attack the nasal symptoms were bad, and there was pain in the ear, but definite discharge going on continuously dates from six months ago, June, 1901. In October, 1901, she came with polypi in the left ear. After removal of these the discharge almost ceased, but the granulation masses began to sprout from a point on the roof of the middle ear, where the probe easily detected bare bone.

Operation (Dec. 14th, 1901).—The tegmen tympani was found eroded and perforated, the upper end of the granulation mass projecting through it, and the

dura mater being exposed. The radical operation was done, the canal split, and the mastoid wound stitched. It was twice dressed before December 26th, when grafting was done. Dismissed from "Home" on January 10th, with the whole tympano-antral cavity skinned except at one small point, at the junction of the graft and the upper meatal flap.

Result.—Complete healing of middle ear. Hearing for whispered speech good.

CASE 3, A. C.—*Obstinate otorrhœa. Mastoid tenderness, erosion of the sinus mastoid wall. Perisinus (extra-dural) collection of pus. Operation. Recovery.*

Case brought to the writer with mastoid tenderness on Dec. 12th, 1903. There was a very small quantity of discharge from a tiny perforation in Shrapnell's membrane. The radical mastoid operation was performed on Dec. 15th. The process was found filled with a large cheesy mass, the sinus-mastoid wall was eroded, and round the sinus a large quantity of cheesy pus was found. There was no reason to suspect infection of the sinus, for the temperature was normal. The sinus was laid bare for an inch of its length, the post-auricular wound was stitched, and the further treatment carried out through the external auditory canal.

Result.—The wound healed in five or six weeks, and the case continues without discharge or symptom of any kind. Grafting was not done.

CASE 4, D. G., *æt.* 12.—*Old-standing otorrhœa. Cerebellar abscess. Operation. Recovery from abscess. Occurrence of hernia cerebelli. Death at later date from an unknown cause.*

Admitted to the Royal Infirmary on March 6th, 1900, with an abscess behind the left ear, and a temperature of 100°, which on the 7th rose to 102°. On March 9th, a Wilde's incision was made down to the bone through the greatly-thickened tissues, and a large quantity of pus evacuated. A large polypoid mass existed in the meatus. The history of the case is one of discharge of a year's duration, and of mastoid pain and swelling of the post-auricular soft parts, of nearly two months' duration, with recently a tendency to be apathetic and to talk less than usual. During the first days in the hospital, he was dull and irresponsive, slept a great deal, face was immobile, but without paralysis, pupils large and equal. The legs were weak, and he could not stand, and could only sit for a few seconds without support. Knee-jerks absent. He complained little of headache, and vomited only on one or two occasions.

After the incision of the soft parts on the 7th, the temperature fell, but oscillated a little, and on the 16th the mastoid cells were freely opened and the granulation masses removed from the canal; but the radical operation was not completed, for the soft parts were still so much thickened that it was difficult to work accurately in the deepest parts of the temporal bone. This operation on the bone was followed by a fall of temperature to the normal, and on March

between the two. The vein should be picked up by an aneurysm needle, care being taken not to injure its walls or to include the nerve in the ligature. The ligatures should be applied at two places, and the vessel cut between.

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26th it was noted that for six days the temperature had been normal or subnormal, but that the left pupil was smaller than the right. At this time the respirations were irregular in rate, varying from 18 to 32, the pulse from 80 to 140, but there was hardly any disturbance of temperature. On March 28th the cerebellum was opened, and a large quantity of pus evacuated. The case did well till April 13th, when the temperature—which since the operation of March 28th had continued almost normal—suddenly shot up to 102·6°. For a week the temperature was disturbed, varying from the normal to about 101·8°. On May 22nd it again resumed the normal; but in the meantime a very distinct hernia cerebelli had formed, and on May 28th the patient was anæsthetized, the cerebellum was searched for further abscess, but without result, and the protruding mass of cerebellar tissue shaved off. The cerebellum again became exuberant, and on July 4th the mass was again excised, but no further collection of pus was found. About this time the patient, who for six weeks was walking about the wards, became anxious to leave the hospital, as he felt quite well, and in spite of protest he ran off to Ireland. Nothing more was heard of him till late in August, when he presented himself at the out-door ear department with his wound nearly healed, but himself looking ill. The writer was on holiday at this time, and the house surgeon, who saw him, arranged that the patient should return for examination by him, but in the interval the patient's father sent word that the patient died after a three days' illness, in his own home. The cause of death, and the details of the symptoms which led up to death, were not ascertained.

CASE 5, W. S., *æt.* 26.—*Old-standing otorrhœa. Mixed intra-cranial infection. Cerebellar abscess, sinus thrombosis, meningitis. Operation for abscess, opening of sigmoid sinus, tying of jugular vein. Death from meningitis.*

He consulted the writer for pain in the ear, on Dec. 18th, 1902. The case was one of chronic suppurative disease of the left middle ear, of eighteen years' standing, commencing in scarlet fever. He was given directions for treatment, and requested to return in two days. On Dec. 20th the writer was called to his house, to find him feverish and with tenderness over the mastoid process. On the 21st, pus was found to be discharging from the posterior wall of the meatus, and the probe struck bare bone there. The pain and tenderness were less. On the 22nd the temperature rose again to 102°, and there was a rigor. The writer recommended immediate operation, but not until next day was permission given, when a second rigor had occurred. He was removed at once to a nursing home, and when on the same afternoon he was put on the operating table his temperature was 104°.

First operation.—The radical mastoid operation was performed. The mastoid cells were found filled with pus, the bone between the sigmoid sinus and the cells was diseased, and the sinus wall itself was surrounded by curdy pus.

Further, the probe was found to pass from the antrum through the tegmen antri into the temporo-sphenoidal lobe of the brain, but no collection of pus was found there. Such tangible cause having been found for the symptoms, nothing further was done. The temperature fell at once to the normal, and remained so for twenty-four hours. On the 25th it reached 101·8°, and on the 26th 103·8°, and a slight rigor occurred.

Second operation.—Suspicions which at the first operation rested on the sigmoid sinus were thus strengthened, and on the 26th the sinus was tested with a needle, but no blood found. The writer therefore proceeded to tie the jugular vein in the neck, afterwards splitting the sinus. The latter was packed. Next day a probe was passed into the jugular bulb from the split sinus, and some decomposing fluid blood brought out. Neither in the sinus nor in the wound was any evidence of decomposition discovered at any subsequent dressing, and no rigor ever again occurred in the subsequent history of the case. On the 27th the temperature again fell to the normal, and for five days the case seemed to go on well, no temperature of over 100·4° being registered. But on Jan. 2nd, 1903, it rose to 103·4°, and on the 3rd and 4th was nearly as high.

Third operation.—On the latter date a disc of bone was removed by the trephine, and the cerebellum searched for pus. Finding none, the writer removed a second disc over the temporo-sphenoidal lobe, again with negative results. The operation was exploratory in intention, neither the pulse nor any other feature pointing to abscess. There was no retraction of the neck, no optic neuritis, no headache, no vomiting. On the other hand there was no definite sign of meningitis except perhaps a little irritability, although of course the possibility could not be excluded. From Jan. 4th till 12th, the temperature continued high: on the 6th it was 105°. Morphia had to be given occasionally for restlessness, slight sickness was common, and once or twice food came back in connection with slight cough. The pulse, which generally had been 100 to 120, fell to 84 to 90. Occasional crying took place, and undoubted retraction of the neck set in. The treatment during the week was by daily injections of anti-streptococcus serum of 10 cc. each. Beyond causing a temporary fall of temperature, these injections did not appear to have any effect. On Jan. 12th the writer determined again to open the cerebellum by removing the bony disc. A very slight use of the probe made pus flow, and it was found to come from just behind the thrombosed sinus. On the following day, the sinus was slit from the mastoid wound into the abscess cavity, and thorough drainage established; in all about three drams of pus were removed from the cerebellum. But in spite of this the symptoms of meningitis became well marked, the pulse rose to 112, coma deepened, the left pupil became contracted, ankle clonus was well marked, the patient passed urine in bed and swallowed badly, and he died late on Jan. 14th (the 28th day, of the acute symptoms).

Post-mortem examination.—The head was opened on Jan. 16th. No changes were noticeable on the upper surface of the brain. The cerebellar abscess was found quite empty, and the cerebellum itself softened and destroyed to the extent of over half its left lobe. The temporo-sphenoidal lobe showed no signs of pus or other evidence of disease. The transverse portion of the lateral sinus was filled with firm, healthy clot. A moderate lepto-meningitis extended across the cerebellum and down into the spinal cord, crossing the middle line of the cerebellum to the right lobe.

CASE 6, A. B.—*Cerebellar abscess. Operation. Recovery.*

Was admitted to Dr. McVail's Ward III, Royal Infirmary, on June 16th, 1902, in a collapsed, semi-conscious state. After admission it was discovered that discharge was coming from the right ear. The note in Dr. McVail's journal states that the right ear was discharging a very foul pus, which was also coming down into the back of the nose along with some altered blood, evidently through the Eustachian tube. The writer was asked to see him on the afternoon of the 17th. He had a slow pulse, a sub-normal temperature; there was a history of giddiness, and of increasing stupor. A foul-smelling pus came from the right ear, and bare bone was detected by the probe in the middle ear. The writer gave the opinion that there was intra-cranial abscess, and advised immediate operation. In the meantime oxygen and stimulants were being used to keep the patient alive. The pulse was slow, the heart sounds weak, the temperature sub-normal, there was copious perspiration, and the general condition of the patient was collapsed. Still, operation was decided upon.

Operation, June 18th, 1902.—The radical operation was performed during the afternoon; the mastoid cells were found filled with foul-smelling pus. The mastoid wound was now enlarged backwards, and the cerebellum searched from this opening. Three or four drams of foul-smelling pus were made to flow from the wound between the blades of the sinus forceps, and the abscess cavity was packed with a strip of iodoform gauze. At once improvement set in. Stimulant was continued, and oxygen administered for some days. Dressing was done every third or fourth day, and at each dressing some pus came from the extended mastoid wound. For the first six days after the operation the temperature was sub-normal (96° to 98°). On the 7th and 17th days after the operation, there was slight rise of temperature, but on both occasions this subsided under a dose of castor oil. No other febrile temperatures occurred. The pulse, which was 60 at the operation, did not rise till the fourth day, when it reached 96. After this date no notable variations occurred. The mastoid wound closed gradually, and the patient was dismissed on August 26th, well, except for a very slight discharge from the middle ear. This patient was last seen at the beginning of 1904, and was then well.

CASE 7, H. McT., *æt.* 19.—*Chronic middle-ear suppuration (unilateral). Operation for cerebellar abscess. Death from abscess on the opposite side of cerebellum (unaffected ear).*

Admitted to the Royal Infirmary on Oct. 24th, 1902, suffering from chronic suppuration of the left middle ear, dating from early infancy. A polypus projected from the left external auditory canal, with an attachment to the tympanic attic. The discharge was very foul. The other ear was normal. The radical operation was performed on Nov. 5th. The bone was sclerosed, the antrum very small, and no other mastoid cells were found. No communication with either the middle or the posterior fossa of the skull was found. The case did well without event till Dec. 2nd, when the temperature rose to 100·4°; on the 6th it reached 103°, but on the 8th it had again fallen to the normal, where it remained for a week. On the 16th the temperature reached 100·6°, and on the 17th 103·6°. During all this time the pulse was slow, generally about 80, but sometimes as low as 60, and it did not reach over 80 on the 16th and 17th, when the temperature sprang upwards. There was also some drowsiness as early as Dec. 9th, but no twitching and no headache. It was pretty clear that there was a brain abscess, but there was very little to guide one as to its locality. On Dec. 25th the writer was summoned, to find the patient much worse, and operated at once, searching both the temporo-sphenoidal and cerebellar fossæ of the left side without result. The patient became comatose, and died on Dec. 29th.

The *post-mortem*, which was conducted by Dr. Workman and Dr. McLaren, showed an unexpected state of affairs. It is given here by Dr. McLaren. "There were one or two small openings into the brain behind the left ear. The abscess was on the right lobe of the cerebellum, very close to the middle line. It had burst into the fourth ventricle, and extended to the third and lateral ventricles. The abscess in the cerebellum was about the size of a garden bean. The membranes on the inferior surface of the cerebellum were somewhat opaque, as if a suppurating inflammation were commencing. There was no sinus thrombosis. Dr. Workman suggests that the disease had extended by the lymphatics."

CASE 8, M. B., *æt.* 18.—*Recent middle-ear suppuration. Jaundice and metastatic joint affections. Meningitis. Death.*

Seen by the doctor in charge on April 11th, 1903, suffering from fever and disturbance of stomach, the latter having lasted a fortnight. The temperature was 102°. There were no lung symptons. The girl complained of pain in the right ear on the 13th, and on the 14th pus was found in the meatus, and there was tenderness over the mastoid process. There were no throat symptoms. The tongue was thickly coated, the bowels constipated, and the breath foul. The temperature fluctuated between normal and 104° till April 29th, when the

tympanic membrane was slit up by the writer, the patient being under chloroform. This gave relief from the symptoms for two or three days, and there was during that time normal temperature; then the right ankle became painful, jaundice appeared, and on May 4th, friction was discovered in the region of the right nipple. Subsequently the first inter-phalangeal joint of the right ring finger became painful and red. The temperature had risen again, and continued so, ranging sometimes to 104°. The pulse was 120. For some time the writer, who was seeing the case with Dr. Leitch, had urged the need for the radical operation, although there had not been any mastoid tenderness since the rupture of the middle-ear abscess on April 14th. The suggestion was, however, discouraged by the parents, and on May 11th Dr. Parry was asked to see the patient. It was agreed that in view of the considerable fall in temperature which had occurred on that morning, operation might be deferred, but that should the temperature rise again, operation should be done at once. The jaundice had in the meantime disappeared, and the joint affections were better. But on the morning of the 12th the temperature rose to 105°, and there was a rigor, so the operation was performed by the writer at 11 a.m. on that day. On the operating table the first signs of a meningitis were displayed, in the form of twitching of the fingers. All the mastoid cells, to the posterior border of the mastoid process, and to its tip, were filled with granulation tissue. The sinus wall was exposed at the knee, but it was bluish and otherwise normal, so it was not opened. The mastoid antrum, which was very deep, was opened after ablation of all the other cells, and was found full of yellowish-green pus. The wound was left open, and packed from behind. The patient died the same night at 7.30 p.m. with a temperature of 106·4°.

The bacteriological examination of the pus taken from the middle ear showed the pneumococcus of Fränckel almost in pure culture, and in such numbers as to suggest that it was the important agent in the infection. The *staphylococcus pyogenes aureus* and a short streptococcus were also found in small numbers.

CASE 9, J. L., *æt.* 18.—*Obstinate otorrhœa. Mastoid tenderness, onset of meningeal symptoms. Immediate operation on mastoid process. Operation for perisinus abscess. Tying of jugular vein. Death from meningitis.*

This was a case of chronic middle-ear suppuration, the result of scarlet fever in childhood. On June 15th, 1904, he was discovered to have a temperature of 103°, and there was a tenderness over the right mastoid process. The writer was called in consultation, and the radical mastoid operation was performed on the afternoon of the same day. All the mastoid cells were found to contain stinking pus. During the operation, the dura of the middle fossa of the skull was exposed, but seemed sound, and was not further disturbed. The posterior wall of the process towards the sinus seemed sound, and the sinus wall was not laid

bare. For three days after this operation the patient did well, but on the morning of the 18th he had a rigor, and the temperature reached 102°. On the

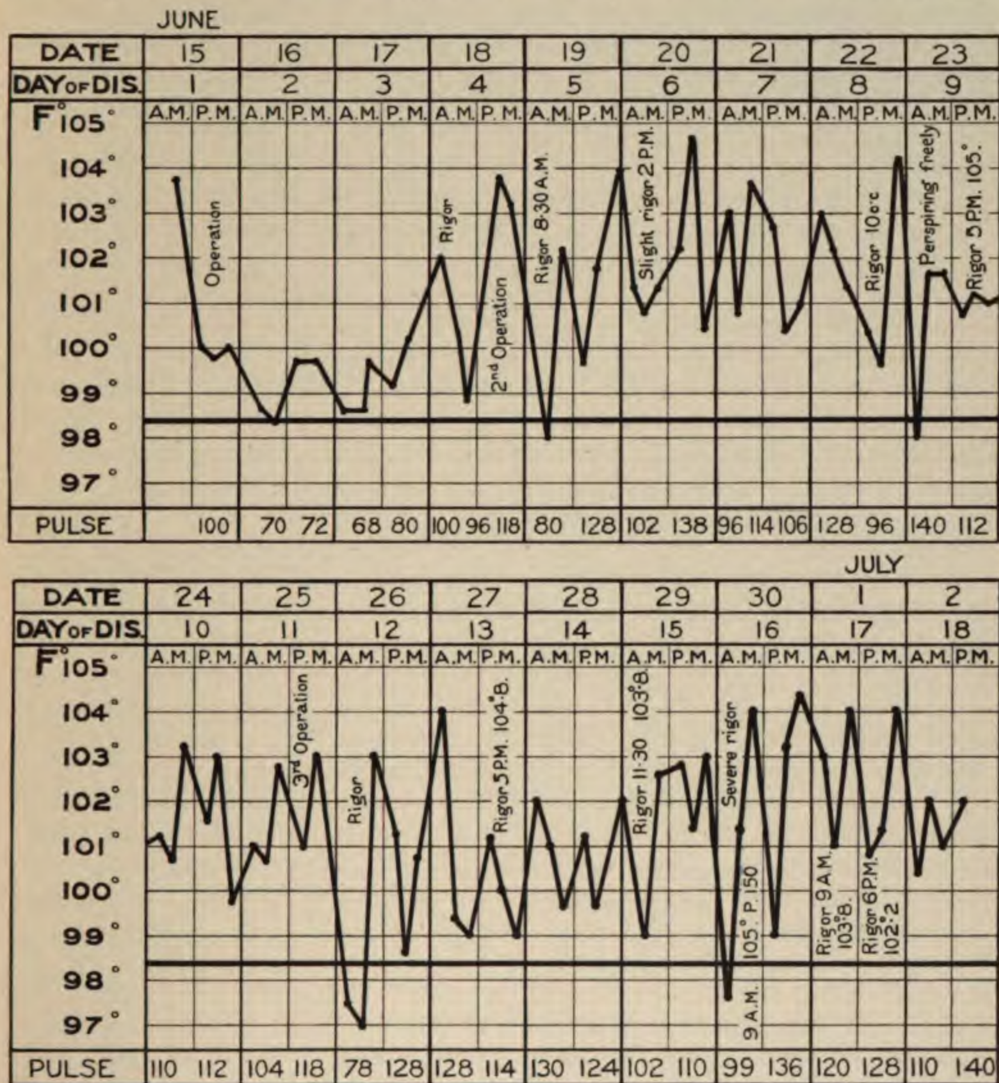

Fig. 57.—Chart of CASE 9, J. L.

same afternoon, therefore, the internal jugular vein was tied, and as a small greenish discoloration of the bone next the sinus wall was discovered, the sinus was laid bare, and a large perisinus abscess evacuated. Here, too, the pus

was evil-smelling. The sinus itself was split and found nearly empty, but its interior was curetted, and its cavity packed with iodoform gauze. For a week the temperature continued to oscillate, usually between 99° and 104°, but on two occasions becoming sub-normal, and on two occasions going above 104°. There were four rigors during this period. From the direction of the jugular bulb a dark-coloured, stinking pus could be mopped out by cotton tips passed well down. The drainage seemed bad, in spite of the fact that the patient was kept lying on the right side, so it was decided on June 25th to carry the bony wound downwards and forwards across the digastric groove into the base of the skull, so that when the patient lay on his back, the jugular bulb would drain into the wound. For a couple of days before the operation a decided swelling appeared on the side of the neck, behind the sterno-mastoid, and as the wound in the neck healed perfectly, the conclusion was drawn that pus must exist amongst the deeper muscles, or perhaps round the jugular bulb itself. This opinion seemed corroborated by the fact that deep pressure over the swelling caused a little pus to well up into the split sinus. During the operation no pus was discovered among the deeper muscles, although after tying the occipital artery a careful search was made. On the 26th, the morning after the operation, the temperature fell to 97°, but about mid-day it rose again to 103°, and a rigor occurred. On this day also the nurse reported that evil-smelling pus had been discovered in the other ear, and on examining this ear, the internal tympanic wall was found to be bare. At first the patient did not seem to think that there had been anything wrong with this ear, but a careful cross-examination brought out the information that this ear, like the other, had occasionally discharged since the attack of scarlet fever in his eighth year. The further history of this case was that of a rather badly defined meningitis. The chief symptoms were high fever, with, however, great remissions, and repeated rigors; the pulse became rapid, ranging from 110 to 160; there was little or no vomiting; the respirations became more rapid, but never displayed the Cheyne-Stokes character; no rigidity of the muscles of the neck occurred, nor did any eye-symptoms appear. The general condition of the patient, however, was that of increasing restlessness, and little sleep was got. On July 2nd there was a good deal of muttering delirium, and as the tension in the brain was found to be very great, an incision was made in the inner wall of the open sinus. In the meantime the wound, including the jugular bulb, had become well drained and comparatively aseptic. A large amount of cerebro-spinal fluid exuded through the incision, but in spite of the relief to pressure thus afforded, the patient became comatose, and died on the same evening. A *post-mortem* examination could not be got.

These cases form a strong argument for the operative treatment of chronic middle-ear suppuration, *before* intra-cranial infection

has taken place. When that infection is a single one, and when no meningitis takes place, *e.g.*, in abscess, the results of operative treatment are good. When the infection is a mixed one, *e.g.*, abscess with sinus infection, the results are still good, although a large number of sinus cases die of pyæmia in some form. When meningitis is added as a complication, recovery is rare.

On the other hand, operation for obstinate middle-ear suppuration which has withstood prolonged cleansing and drying, is a safe procedure; and if practised more largely, would anticipate many of the intra-cranial complications which occur, and reduce the death-rate from middle-ear disease. A study of the history of the case, the presence or absence of mastoid tenderness or pain, and the use of the mirror and speculum, will enable the practitioner to select the cases suitable for operation.

Ear Disease and Life Insurance.—If suppurative middle-ear disease is such a constant menace to life, its existence must be taken into account in examining candidates for life insurance. But it is not necessary to slump these cases, and reject all applicants who have or have had continued discharge from the middle ear. Discharge which has ceased, even if it had lasted for years, should not be made the reason for rejecting a life. If the perforation in the tympanic membrane have healed, and if no discharge have occurred for some years, the life may be taken at ordinary rates. If the middle ear be open, much of the tympanic membrane having disappeared, the life should be taken only at an extra, for the tissues within the middle ear are more vulnerable to attack from the direction of the Eustachian tube and the external auditory meatus than those of a healthy tympanum, and the patent perforation makes such attack much more likely; *e.g.*, by the entrance of dust, or (during sea-bathing) of water. It is better not to accept a case of uncured chronic middle-ear discharge at all. If acceptance be insisted on, the extra must be a high one. If there be mastoid tenderness, or a history of mastoid pain, the life should be absolutely rejected. If the discharge cease as the result of treatment, and continue absent for a year, mastoid complications,

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CHAPTER X

DISEASES OF THE INTERNAL EAR.

Nebulous condition of our Knowledge of these Diseases—Etiology of Internal-Ear Deafness—General Symptoms—Menière's Disease and Symptoms—Inflammation of the Labyrinth—Syphilitic Disease of the Internal Ear—Internal-Ear Disease due to other Constitutional States—Otalgia—Aids to Hearing.

ON the whole, our knowledge of the etiology and diagnosis of the diseases of the ear which up till now we have been considering, is exact. It is different with regard to the last group of diseases which must come under review—diseases of the internal ear. This contrast is due to two causes. The internal ear cannot be seen through a speculum, nor tested by a probe; and, although we can in testing it bring to bear the special stimulus for the reception of which it exists—sound—this, as we shall see, carries us but a short way towards exact or accurate diagnosis. In the above respect, the eye affords a striking contrast to the ear; for the expansion of the optic nerve can be examined by the ophthalmoscope, in a way in which it is impossible ever to examine the expansion of the auditory nerve. The second reason for the want of definition in the diagnosis of the different conditions which affect the internal ear, is that the opportunities for correcting clinical observation by subsequent *post-mortem* examination are necessarily few, and the manipulations for thoroughly carrying out the latter are difficult and tedious.

In this latter respect, diseases of the internal ear stand out in striking contrast to the suppurative middle-ear affections which cause intra-cranial complications. It is only recently that we have been put in possession of anything like a true pathology and effective treatment of these intra-cranial complications. When death does

follow such complications, the event is not long deferred, and it is easy to lay the morbid conditions alongside the clinical manifestations and complete the picture. But internal-ear diseases seldom kill their victims; when death occurs it is from some probably unassociated cause or disease, and happens long after the onset of the deafness. These facts, taken along with the great difficulty of making examination of the internal ear after death, account for the nebulous state of our knowledge on this subject.

By sound tests, as we have seen (pp. 64-81), it is generally possible to distinguish an affection of the sound-*perceiving* from one of the sound-*conducting* apparatus. In the case of deafness due to the former, the sound tests show a decided diminution of the duration of bone-conduction hearing (Schwabach's test); a superiority of aerial over bone-conduction hearing (Rinne's test) +; and a lowering of the upper tone limit (deafness for the highest notes). If along with these results it be found by examination with the mirror and speculum that the tympanic membrane is normal, and if the Eustachian tube be patent, disease of the internal ear, of the auditory nerve, or of the auditory centres, may be diagnosed.

The commonest cause of disease of the internal ear, is previous disease of the middle ear. Any acute disturbance in the tympanum, may set up temporary disturbance in the labyrinth. This it does by altering the normal pressure conditions within the labyrinth, as conducted thereto by the round or oval windows, or by altering the normal circulatory conditions, and causing anæmia, hyperæmia, or even bleeding. In the non-suppurative inflammations of the tympanum, in caisson disease, and in anything which suddenly or for a long time alters intra-tympanic pressure, secondary labyrinthine changes often occur. In this connection otosclerosis, either *per se* or associated with naso-pharyngeal affections, should be specially remembered; the labyrinthine affections in otosclerosis being, however, due to trophic changes in the bony capsule of the labyrinth.

In suppurative middle-ear affections, the labyrinth is often involved in the infective and destructive processes, although

considering the extent to which these processes invade surrounding structures (mastoid, brain, etc.), it is astonishing how seldom the labyrinth is involved. Fistulous openings into it occur often in the middle-ear complications of the infectious fevers—scarlet fever, measles, etc. Cario-necrotic changes occur to a limited extent, even in the more innocent forms of middle-ear suppuration, and to an extent sometimes involving the whole labyrinth, in the tubercular affections of young children.

From the side of the brain, the labyrinth is often threatened, and may be quite destroyed. This is most commonly the case in deaf-mutism, where the cause of deafness is almost always labyrinthine, and where the causative disease is oftenest meningitis and epidemic cerebro-spinal meningitis. Brain affections of any kind—abscesses, tumours, etc.—may by pressure cause deafness, which, whether labyrinthine or not, is at least a nerve deafness.

Nervous deafness is sometimes due to *injury*, as the result of accident in which the skull is fractured or otherwise injured by falls, blows on the head, etc. The action of very loud sounds—explosions, the noise of rivetting, boiler-making, etc.,—produces labyrinthine deafness, either suddenly or by long-continued action on the expansion of the auditory nerve.

Many *drugs*, administered internally, disturb the labyrinth. The chief of these perhaps are, quinine, the salicylates, and tobacco.

Hereditary tendency is a common factor in the etiology of labyrinthine disease. If we exclude deaf-mutism, this tendency is oftener displayed about middle life as an otosclerosis, than in childhood, but hereditary syphilis accounts for a good many cases of internal-ear deafness during the earlier decades of life.

GENERAL SYMPTOMS.

The general symptoms of disease of the internal ear are: (1) *Deafness*: (2) *Giddiness*; (3) *Subjective noises*, or *Tinnitus aurium*.

1. **The Deafness** which attends disease of the internal ear is seldom moderate in degree; it is either very profound, or very slight. Hæmorrhage into the labyrinth, syphilis of the labyrinth,

destruction of the labyrinth by meningitis or by the acute infectious fevers, destroy the nervous elements either in whole or in part. Similarly, the prolonged action of loud sounds produces a high degree of deafness, although the nervous elements are not annihilated here. On the other hand, hyperæmia and anæmia may produce only a slight or even a temporary deafness. The cases in which a moderate degree of deafness results from a labyrinthine affection, are those in which the internal ear has become affected by the spreading from the middle ear of a non-suppurative lesion, and here the middle ear is usually the chief cause of the deafness.

Hearing may exist only in *patches* or *islands*, parts of the cochlea being destroyed, while the parts left are partly injured, or intact. This will be fully illustrated when discussing deaf-mutism, as it is amongst deaf mutes that this peculiarity is almost exclusively found.

In most cases of deafness due to disease of the labyrinth, and in many cases in which a labyrinthine affection has succeeded a non-suppurative middle-ear disease, there is great lowering of the upper tone limit. This is not surprising, when we consider that appreciation for high notes belongs to that part of the cochlea which lies next the middle ear (*see Plate II*). On the other hand, in cases of internal-ear deafness, hearing for upper tones may be all the hearing that is left, and by its presence may afford all the appreciation for lower tones—tones of the voice—which exist. The primes of the voice tones are unheard in these cases, but the higher partials are, and there is reason to suppose that appreciation for vowel sounds may thus be preserved, *e.g.*, in certain cases of deaf-mutism.

When the degree of deafness *varies* much, the usual cause is alteration of the air-pressure within the middle ear. Such variation indicates a recent as against a chronic middle-ear affection, and is of hopeful prognosis. Variation in hearing may occur also in labyrinthine affections when the auditory nerve becomes fatigued, when the attention of the deaf person is distracted by several voices speaking at one time, and when the deaf person is fatigued or indisposed. Such variations are most marked in neurasthenic individuals.

Paracusis, in the sense of depraved or aberrant as against deficient hearing, may take the form of *paracusis loci*, in which a patient who has lost the hearing in one ear fails to determine the direction from which a sound proceeds. This aberration of hearing characterizes many cases in which, either by nature or by operation, all active disease has long since been made to cease.

Paracusis Willisii is the term given to that peculiarity by which many deaf persons hear better in a noise, such as that of an engineering shop, or when travelling in a railway train. It has been explained by supposing that the violent vibration makes the stiffened or ankylosed ossicles more receptive to sound-waves, or that the ordinarily irresponsive auditory nerve is made more responsive by the action of violent vibration. It probably means that a middle-ear affection is well established, and that secondary changes in the labyrinth have already begun.

Hyperacusis, or over-sensitiveness of the auditory nerve, characterizes the early stages of many of the acute fevers, and the early stages of some cases of otosclerosis. It is also a feature of some cases of mental excitement.

A rare condition, met with in some cases of labyrinthine disease, is the appreciation of the same note as of two different pitches. The writer has met with this peculiarity in a musical patient, who suffered from a middle-ear catarrh of some months standing, whose hearing ultimately improved greatly, and from whose case the peculiarity here noted ultimately disappeared. It was probably due to some local increase of tension within the labyrinth of the affected side.

2. **Vertigo or Giddiness,** as a symptom of aural disease, is much less frequent than either deafness or tinnitus. It is sometimes due to a cause within the external auditory canal, such as a foreign body or a mass of cerumen. Oftener it is caused by syringing the ear, in the effort of the practitioner to remove these obstructions. When the membrane is perforated, the current of water from the syringe may cause vertigo by its impact on the stapes or on the exposed fenestræ. Manipulation about the ossicles—if the

instrument used disturb the stapes—may set up vertigo. In any middle-ear disease vertigo indicates either an increase of intra-labyrinthine pressure, or in suppurative middle-ear disease it may mean the invasion of the labyrinth by the purulent process. Vertigo may also be caused by the sudden increase of intra-tympanic pressure, occurring during inflation of the middle ear.

Vertigo is a symptom in many cases of internal-ear disease. When it is very violent, very sudden, is accompanied by deafness and tinnitus, and by vomiting and general collapse, the combination constitutes the symptom-complex of *Menière's disease*—hæmorrhage into the labyrinth. Occurring as a symptom during an intra-cranial complication of a middle-ear suppuration, vertigo indicates a cerebellar abscess or a meningitis. Vertigo due to extra-aural causes is very common. The commonest of these causes are probably gastric disturbances and arterio-sclerosis. In these cases tinnitus and deafness are usually absent, but in no case of vertigo should an examination of the ears be omitted. Like tinnitus, vertigo is an uncommon symptom in the ear affections of children. The age of the patient, his habits, and the presence or absence of other ear symptoms, enable the practitioner to localize its cause in most cases.

3. **Tinnitus Aurium.**—Tinnitus as a symptom has been noticed in connection with many of the diseased states of the external and middle ears. It is present also in the diseases peculiar to the internal ear. Further, it is a feature of many general conditions in which the ear, apart from the tinnitus, is not involved. A review of the causes of tinnitus will tend to the proper appreciation of this symptom.

The aural causes of tinnitus are numerous. Ceruminous collections, aural polypi, and foreign bodies in the external auditory canal, all cause tinnitus. The symptom is not an invariable result of such conditions—indeed it is oftener absent than present—and it disappears on the removal of the cause. It is usually only moderate in degree. It is, if there is no middle-ear affection present at the same time, a reflex conveyed by the fifth nerve. The use of

the aural syringe, and manipulations within the tympanic cavity, may give rise to tinnitus. As a symptom of middle-ear disease, tinnitus is very common, and certainly occurs in more than half the cases of middle-ear disease which come before the practitioner. In inflammations of the tympanic membrane, in acute catarrh of the middle ear, and in acute suppuration within the tympanum, tinnitus is the rule. Even when no serious secondary labyrinthine affection is set up by acute inflammation of the middle ear, there is hyperæmia of the labyrinthine vessels, and tinnitus is the result. The symptom is also in many of these cases due to pressure exerted through the fenestræ by the fluid contents of the tympanum. When the middle-ear inflammation subsides, or when the tension within the drum cavity is relieved by rupture of the tympanic membrane, the tinnitus disappears. Alterations in the tympanic air pressure occurring during acute middle-ear inflammations, also produce tinnitus—the intra-labyrinthine pressure varying with that of the tympanum, and that of the latter cavity varying with the amount of obstruction of the Eustachian tube.

Tinnitus is a fairly common attendant on chronic suppurative processes occurring within the tympanum; and here the cause is usually the presence of discharge, which disturbs the equilibrium of the ossicular chain, or the presence of cicatricial bands, which by driving inwards the foot-plate of the stapes, increase labyrinthine pressure. But it is in chronic aural catarrh, and in otosclerosis, that tinnitus is most common amongst middle-ear affections, and in which it assumes its most persistent and distressing forms. In otosclerosis it is sometimes the only symptom complained of. It is nearly always the earliest, and frequently the most distressing symptom. In these conditions, when the tinnitus is variable or occasional, the immediate cause is Eustachian obstruction. When it is constant, and is not influenced either by weather changes or by artificial ventilation of the tympanum, the immediate cause is either cicatricial contraction of connective tissue formations within the middle ear, which permanently cause increased labyrinthine pressure, or a secondary labyrinthine affection. The uniform

persistence of tinnitus in middle-ear affections is of bad omen. Its occasional presence, unless there be a very high degree of deafness, warrants a favourable prognosis. All tinnitus is due to an irritation of the expansion of the auditory nerve in the labyrinth, or to an irritation of the nerve itself, or to the auditory centres in the brain. The causes which have hitherto been considered, although intra-aural, are all extra-labyrinthine. The tinnitus caused is either due to mechanical pressure, to circulatory disturbance, or to reflex action. Primary labyrinthine affections are almost all attended by severe tinnitus. In labyrinthine apoplexy, the tinnitus is an immediate, a violent and a lasting symptom, though it is not usually so lasting as the deafness. In labyrinthine syphilis, the subjective noises are very intense, last indefinitely, and may give annoyance even after there is almost complete deafness.

Tinnitus aurium may be due to tumours or abscesses within the brain causing disturbance of the auditory centres, or to pressure of bony growth situate at the base of the skull, and exerted upon the auditory nerve at some part of its course. The extra-aural causes of tinnitus are mostly reflex. The commonest path is by the fifth nerve from the mouth and gums in diseases of the teeth, and from the nose and pharynx. It is probable that tinnitus is produced in this way from more distant organs, such as the stomach.

In none of these forms of tinnitus does sound—the usual stimulus of the auditory nerve—play any part. The symptom is therefore purely subjective. A symptom similar to tinnitus in character, but quite different in origin, because depending on sounds actually produced within the body, has been described as *entotic*. It is purely objective, and depends on sounds occurring in structures contiguous to the ear. Such sounds are: the venous hum occurring within the veins in anæmia, most readily heard in those cases in which the jugular bulb is unusually placed upwards and forwards towards the tympanic cavity; the pulsations of the carotid, best heard also when this vessel is displaced upwards and backwards towards the tympanic cavity; the movements of air and mucus—râles—in the middle ear and Eustachian tube; and the contractions

of such muscles as the tensor veli palati and the tensor tympani. The long continuance of sounds of one pitch, even if these be not very intense, gives rise to more or less troublesome though temporary tinnitus. The writer has experienced it when testing deaf mutes with Galton's whistle and with the pipes of Bezold's continuous tone series. A patient of the writer's, only ten years old, had a clicking sound set up by practising on the piano. The cessation of practising for some days stopped the tinnitus, but it again returned when the exercises were resumed. It was ultimately necessary to give up the exercises altogether. The clicking was quite regular, and was quite without the control of the patient. It was only partially relieved by such medicines as the bromides.

Such drugs as quinine and the salicylates are well known to give rise to distressing tinnitus aurium. Alcohol and tobacco have the same effect. Tobacco probably acts as a toxic agent, and also causes tinnitus by setting up hyperæmia of the pharynx and Eustachian tube; alcohol by producing disturbance of the labyrinthine circulation, and by its toxic effects. Allied to tinnitus aurium, but really of psychical origin, are aural hallucinations, in which voices, singing, and melodies are heard. These generally indicate some form of mental disturbance, but cases occur in which the patient is quite sound in mind.

Subjective auditory sensations vary like actual sounds in pitch, in intensity, and in quality. They are described by patients as being like hissing, bubbling, whistling, rushing of water, ringing of bells, etc. They are not always disagreeable, being often musical in character. They are disagreeable chiefly because of their persistence and intensity. They are sometimes so intense as to cause the patient great distress, and often he states that were the sounds to cease, the deafness which so often accompanies them would cease. When slight, subjective sounds are often unheard, or at least are covered up by the actual sounds going on around the patient. Pre-occupation also renders the patient unconscious of the milder varieties of tinnitus. Subjective sounds are for both these reasons worse at night, and sometimes make sleep impossible. When high

pitched, tinnitus is said to denote an internal-ear affection, when low pitched, an affection of the sound-conducting apparatus. This is a distinction which cannot always be drawn clinically, both because aural affections attended by tinnitus are often mixed—that is, consist of affections of both middle and internal ears—and because in unmixed affections the rule involved in the above statement does not always hold. It would perhaps be truer to regard the pitch of the tinnitus as indicating the part of the cochlea which is disturbed, tinnitus of high pitch being due to irritation of the section of the cochlea next the oval window.

THE PROGNOSIS in tinnitus aurium is good when the cause is in the external auditory canal, and when the symptom is the result of an acute inflammation of the middle ear. In cases due to an extra-aural cause, the prognosis is generally good. On the other hand, in chronic aural catarrh, in otosclerosis, and in most of the affections of the internal ear, *e.g.*, hæmorrhage, syphilis, etc., no promise of absolute cure should be given. Speaking generally, recent cases, even if the tinnitus be severe, can be cured; obstinate long-standing tinnitus can less often be entirely removed. Tinnitus which varies with the weather, especially that which varies with the patency of the Eustachian tube, can be removed. Tinnitus which varies in intensity with the general nervous condition of the patient, is less amenable to treatment, though partial relief can generally be obtained. This type, which also varies with such external conditions as those of the weather, is generally due to circulatory disturbance within the labyrinth, or to reflex causes, and is not governed by the conditions of air-pressure within the middle ear.

THE TREATMENT of tinnitus aurium is that of the condition on which it depends. The cause should be carefully sought out, and this involves not only a careful examination of the ear, but a careful study of the case as a whole. Reflex causes within the mouth and throat, and in the external auditory canal, should be removed. When there is disease of the middle ear, success in treatment will vary according as this disease is of recent origin or of old standing. In chronic aural catarrh, and especially in otosclerosis, the

symptoms may be so distressing that even operation on the middle-ear structures may be advisable. But the effect of such operation is not usually permanent. Some alleviation generally follows the careful regulation of the air pressure in the middle ear, the rarefaction of the air within the external auditory canal, and the movements of the intra-tympanic structures effected by pneumo-massage. In all cases of troublesome and obstinate tinnitus, it is well to proscribe entirely alcohol and tobacco. In neurotic individuals, whether there be middle-ear disease or not, the bromides give relief, but hydrobromic acid has not been followed by such good results in the author's experience as in that of many writers. Counter-irritation over the mastoid process does not give striking results. Any turbinated hypertrophy, especially if it interfere with the freedom of nasal breathing, should be surgically dealt with.

DISEASES OF THE INTERNAL EAR.

Labyrinthine Hæmorrhage (Menière's Disease).—Exudation and hæmorrhage into the labyrinth may occur as the result of various diseased conditions, such as hyperæmia, meningitis, syphilis, etc., but when this occurs suddenly and unassociated with other discoverable lesions, the condition is known as Menière's disease. In 1861, Menière described the case of a girl who suddenly became deaf, with symptoms of giddiness and vomiting, and died five days afterwards. The *post-mortem* examination showed the vestibule filled with reddish plastic material, whilst the cochlea was normal. The girl was healthy, but caught a cold at her menstrual period. Cases of this kind are not common, but have been noted often enough to warrant their being grouped provisionally as cases of Menière's disease, although it is quite likely that in time the condition may be found to be due to causes so different, and so associated with other lesions, that the group as a separate one may disappear, and the separate cases be relegated to their proper headings. In the meantime, it is important to note that the so-called typical Menière's symptoms sometimes occur where *post-mortem* examination demonstrates the labyrinth to be sound, and that the above described

bleeding and exudation sometimes takes place without any occurrence of the above-mentioned symptoms.

Regarding Menière's disease as a labyrinthine apoplexy, the symptoms are dizziness, noises in the head, and great deafness coming on suddenly. There is sickness or vomiting, and symptoms of general collapse, the individual falling as if struck down, and losing or almost losing consciousness. The face is pale, and bathed in copious perspiration. When he tries to rise he staggers, and there is great deafness either in one or both ears, lasting for a long time or becoming permanently established. The further course of the disease is variable; but unless there be relapses, the more acute symptoms—vomiting, giddiness and pallor—begin to pass off in a day or two, whilst the deafness and tinnitus, especially the former, are more or less permanent, and in the worst cases permanent in the highest degree. There may also be staggering gait for a long time.

Examination by speculum shows the middle ear and throat to be unaltered, whilst the testing of the cranial nerves, other than the auditory, puts a brain affection out of the question. If the examination of such organs as the kidney, the spleen, etc., and the other features of the case should prove an intercurrent nephritis or leukæmia, or if the examination of the blood show a pernicious anæmia, symptoms of Menière's disease may be regarded as due to labyrinthine apoplexy, to which these maladies have predisposed the patient.

Many affections of the ear are attended by symptoms similar to those of labyrinthine apoplexy. Giddiness and tinnitus, with or without deafness, but with sickness or vomiting, are often referred to as *Menière's symptoms*. Such symptoms may be due to a central nervous lesion, in which case absence of evidence of an intra-labyrinthine affection, absence of any objective evidence of middle-ear affection, should make the practitioner look for disturbance in the other cranial nerves or in the nervous centres in the brain itself. But the group of symptoms above described may be due to a middle-ear affection, such as chronic aural catarrh. In this

case, the symptoms are due to increased labyrinthine pressure, the foot-plate of the stapes being driven in by the retracted membrane, or by adhesive processes. In otosclerosis, the same symptoms may be due to the same agencies, but the bony growth may act independently by encroaching on the labyrinth.

Anything which suddenly disturbs labyrinthine pressure may produce the symptom-complex. On one occasion, the writer, after extracting a loose necrosed stapes, produced all the symptoms very acutely by insufflating a powder into the ear by the small perforation through which the stapes had been brought, with almost no pain. Immediately there were giddiness, vomiting, tinnitus, and symptoms of general collapse, and in a few minutes violent diarrhœa. The symptoms passed off in a few hours, and the deafness—a feature of the case before the powder insufflation, but which was made worse by the operation—returned to its former condition in two or three weeks.

In suppurative diseases of the middle ear, Menière's group of symptoms follows any sudden extension of the disease into the labyrinth, for example, by the formation of fistulæ into the vestibule or semicircular canals. Manipulations within the middle ear may bring about the same, or even severer, symptoms. In one case of the writer's, the syringing and dressing of the middle ear brought on a typical epileptic seizure. A commoner result of syringing is the production of giddiness. Within the external auditory canal, the presence of a foreign body may cause the group of symptoms under discussion.

The Treatment of labyrinthine apoplexy is that by perfect rest in bed, cold to the head, mustard to the nape of the neck, and a smart purgative. The room should be darkened, and perfect quiet enforced. The diet should be light, cool, and of fluid consistence. Bromides of soda and potash may be tried as soon as the symptoms of collapse have passed off. Quinine has perhaps the greatest reputation in this disease, but the dose should not be over ten grains in the twenty-four hours. Iodide of potash in five- to ten-grain doses may be given, either alone or along with the bromide

of potash. After several weeks, if there be still giddiness and deafness, pilocarpine may be administered, either by the mouth or subcutaneously, in doses of about one-sixth of a grain, with the view of helping absorption of the effused products.

The treatment of the milder cases of Menière's symptoms is that of the middle-ear affection on which they depend, or of which they are an extension. In non-suppurative cases, treatment is carried out at first through the Eustachian tube, and only if this fails, would division of folds of the tympanic membrane or bands within the tympanic cavity, or of the tensor tympani muscle, be warranted.

Labyrinthitis.—Primary inflammation of the labyrinth has been described by Voltolini as occurring in young children. There are fever, flushing of the face, vomiting, delirium, convulsions and coma. Recovery takes place in a week or less, but deafness, usually total, remains. The symptoms are those of a meningitis, the chief difference from which is that the disease runs a much shorter course. Whether, indeed, these cases are not really cases of meningitis, remains for the present a matter of doubt.

Secondary inflammations of the labyrinth are very common. The spreading of pathological processes to the labyrinth from the middle ear, when the latter has become the seat of chronic aural catarrh and otosclerosis, has been noticed (*see p.* 145). The pathways by which pus reaches the labyrinth during the course of middle-ear suppuration, have also been noticed (*see pp.* 162 *and* 278).

In these two classes of cases, the pathological changes are not the same. In the non-suppurative cases, the branches of the auditory nerve, and particularly those of the cochlear nerve, become atrophied. The ganglionic cells which occupy the spiral canal of the modiolus, and which give off the terminal branches of the auditory nerve, become, along with these ultimate nerve branches, shrivelled. This change is most marked in the branches given off to the first turn of the cochlea. In a purulent inflammation of the labyrinth, parts of the latter structure are more apt to be destroyed *en bloc*, leaving other parts more or less uninjured. Once pus has entered the labyrinth,

it does not confine itself to one division of it, and the cochlea is almost always involved, even if the introduction have taken place by a semicircular canal or the vestibule. The resulting changes are, in the event of recovery of the patient, the absorption of pus, the degeneration or organization of hæmorrhages and inflammatory products, the replacing of nerve cells and endings by connective tissue and bone, and the destruction of hearing.

The labyrinthine affection may be, in purulent inflammation, but the link towards an intra-cranial complication. On the other hand, the labyrinth, and through it the middle ear, may be attacked from the side of the brain. So far as the labyrinth is concerned, this must be accounted a common occurrence ; so far as the middle ear is concerned, a rare one. The anatomical changes which destroy hearing when the labyrinth is affected, by the spreading of a meningitis, will be best illustrated when discussing deaf-mutism, which in many cases is due to meningitis.

The changes causing the deafness may take place either in the floor of the fourth ventricle, where the lining membrane may become the seat of purulent infiltration ; at the root of the auditory nerve, where fatty degeneration and atrophy may set in ; during the course of the auditory nerve, which may become degenerate or may get embedded in the exudation thrown out on the meninges ; or in the labyrinth, which may become the seat of purulent exudation. From the labyrinth, the purulent process may extend to the middle ear, the tympanic membrane of which may become perforated, as in a primary otitis media purulenta. As a rule, both ears are affected, and the hearing is permanently ruined. In a case of traumatic meningitis—the result of a fall—which came under the care of the writer, and which ran a very prolonged course, the hearing was destroyed in one ear, and the sight almost destroyed in both eyes, but there was no purulent affection of the middle ear.

The most profound and striking effects of suppurative disease within the labyrinth occur during the course of scarlet fever, diphtheria, measles, and meningitis. The labyrinthine affection is generally secondary to middle-ear disease, or to a brain disease,

but may be simultaneous with these, and the symptoms of the ear affection are masked by the other acute symptoms of the septic process, of which the ear disease is only a small part. The symptoms of an acute secondary labyrinthitis are fever, giddiness, convulsions, and coma. If recovery takes place, the giddiness, which for a time may be evidenced by a staggering gait, disappears; but the deafness is permanent.

In the adult, it is in connection with the *chronic* rather than the acute purulent processes within the middle ear, that secondary labyrinthine suppuration most commonly takes place. The labyrinth in the adult is well walled in by a capsule of compact bone, and it is when some part of this capsule is worn through by persistent cario-necrotic processes, that infection of the labyrinth occurs. It is quite exceptional for the adult labyrinth not to be able to withstand a single acute attack, just as it is very exceptional for intra-cranial affections to follow acute middle-ear inflammations. The anatomical conditions are similar so far as the protection of the threatened structures is concerned. But the case is different in children, especially in tuberculous children. Here, even in acute diseases, the labyrinth succumbs to the attack with ease (*see p.* 189 *et seq*).

In chronic middle-ear suppuration occurring in adults, the labyrinth is more commonly involved than has hitherto been supposed. The labyrinthine structures become infected through some breach in the bony wall. Hinsberg found that this fistula most commonly occurred in the horizontal semicircular canal, next in frequency by the fenestra ovalis, less frequently through the wall of the promontory, and very seldom by the two other semicircular canals, or by the fenestra rotunda. The destruction within the labyrinth may be very slight, and may be confined to one section of the labyrinth, such as the semicircular canal primarily involved. On the other hand, the disease may spread from one section to another, and in tuberculous cases is apt to destroy the whole labyrinth, which may come away in time as a sequestrum. Further extension may take place from the labyrinth to the cranial cavity, the commonest path for such infec-

tion being the internal auditory canal to the cerebellar fossa. This is a source of intra-cranial infection which is not generally recognized, and not carefully searched for by practical surgeons. But both meningitis and cerebellar abscess have been thus traced in some cases. It should be remembered that facial paralysis may result in such a case without any involvement of the nerve in the middle ear or in its descending part through the mastoid process, for the facial nerve passes outwards with the auditory nerve along the internal auditory meatus.

THE SYMPTOMS of labyrinthine suppuration may be slight or very acute. Mere irritation may cause vertigo and nystagmus; destruction of the labyrinth causes deafness, staggering gait, or both, according as the cochlea or the semicircular canals, or both, are affected. When death occurs, it is usually by meningitis. When recovery takes place, there may be deafness, or if only the semicircular canals be involved, little interference with hearing may arise.

THE DIAGNOSIS of labyrinthine involvement in suppurative middle-ear disease is made, if internal-ear deafness rapidly or decidedly develop during the course of a middle-ear suppuration; and less doubt exists if, along with the deafness, there be attacks of giddiness, of sickness, and of tinnitus. The similarity of these symptoms to those of cerebellar abscess must be remembered.

THE TREATMENT of secondary labyrinthine suppuration depends on the diseased condition from which it has arisen. In meningitis, in scarlet fever, etc., treatment so far as the deafness is concerned is generally a failure. Cold should be applied to the head, or local blood-letting may be adopted. After the acute stages are over, an attempt may be made to produce absorption of recent exudate by the administration of iodide of potash; later still, pilocarpine may be used with a similar object; but unless a fair amount of hearing is preserved, either in whole or in parts of the musical scale, persistent treatment, either by these measures or by electricity, cannot be expected to do good.

Operative treatment in acute secondary labyrinthine suppuration

attending the acute fevers or meningitis, can hardly be carried out, partly because in many of the apparently worst cases the patient recovers, though the hearing is permanently lost, and partly because even a successful exploration of the labyrinth would not remove the chief danger to the life of the patient, and of course would not restore his hearing.

On the other hand, the operative treatment of suppuration within the labyrinth occurring in the course of a chronic middle-ear suppuration is not only justifiable, but gives the only rational hope of limiting the disease, and preventing the intra-cranial complication which so often develops and causes the death of the patient. The outlook is bad in any case, but it is distinctly better if the labyrinthine abscess can be drained. The operation is the radical mastoid operation, the middle ear being thoroughly opened up and the internal tympanic wall carefully examined for any fistulous opening from the cavity to the internal ear. If such be found, it may be widened either by a fine burr or by a curette. Granulation masses should be carefully removed, and the sinus followed into the vestibule or cochlea if required.

Hinsberg thinks that whenever the labyrinthine suppuration demands operation at all, the cochlea should be opened, for it either is, or will become, affected. He gives the following technique of the operations on the labyrinth: (1) Radical operation, the posterior wall (facial spur) being removed sufficiently to expose the region of the foramen ovale; (2) Opening of the foramen ovale, and then (if opening of the cochlea is intended) removal of the promontory; (3) Introduction of a probe through the oval window, and under its guidance, opening of the vestibule from the horizontal canal along its anterior crus, or under difficult anatomical conditions from behind. A chisel should not be used, a fine burr being safer, and in proceeding downwards and forwards on the promontory, care should be taken that the carotid artery, which is sometimes abnormally high, is not injured.

Post mortem examination tends to show that a quiescent purulent inflammation of the labyrinth may be lit up by the

mastoid operation when the latter is performed for the cure of an obstinate middle-ear suppuration. This might be used as an argument against the use of the radical mastoid operation performed as a prophylactic measure. It is rather an argument for the more thorough performance of the operation, for the thorough exposure of the internal tympanic wall, and for the discovery and operative treatment of any sinus which exists in that bony partition.

Syphilitic Disease of the Internal Ear.—Amongst the more definite causes of profound deafness due to disease of the internal ear, must be regarded syphilitic disease. In any large clinique many cases occur, in which the deafness comes on somewhat suddenly, becomes very profound, and persists in spite of all efforts to remove it. In most of these cases there is no middle-ear disease to which the labyrinthine affection has become secondary—although in some such a connection exists—there is no question of meningitis, the symptoms are not those of a labyrinthine apoplexy, and there is no exanthem or other febrile affection to account for the appearance of the deafness. But there is a history of syphilis, and in many cases there is (either in the eye or in the teeth amongst young subjects) evidence that the patient has hereditary syphilis; while amongst older subjects evidence of syphilis may be got, or careful enquiry may elicit an admission of infection.

DIAGNOSIS.—In syphilitic affections of the labyrinth, the deafness is the constant feature. This comes on pretty suddenly, or at least advances fairly rapidly, much more so than is usually the case in otosclerosis or chronic aural catarrh. Tinnitus, and even giddiness, may be well-marked symptoms, but are neither so uniform nor so intense as in Menière's disease, and there is neither sickness nor vomiting. Unless there be a co-existing middle-ear affection, otoscopic examination may show nothing; but co-existing middle-ear affections sometimes occur, both suppurative and non-suppurative. Similarly, the Eustachian tube may be swollen, the throat patched with specific ulcers, and thus the middle ear may show the objective phenomena due to these conditions.

Inflation does not improve hearing, as it so often does in a recent middle-ear affection. Hearing tests show a labyrinthine affection. Bone conduction is much shortened, or has disappeared. Rinne's test gives a positive result, as in all cases where the labyrinthine affection predominates that of the sound-conducting apparatus; and when Weber's test is applied, the sound is lateralized, if at all, towards the less affected ear.

To confirm the diagnosis, evidence of syphilis should be sought for in the throat or the lips, and inside the cheeks and on the genitals. It is at the end of the second, or during the third stage, that labyrinthine syphilis most frequently develops, and it is most commonly seen in untreated cases. If evidence of secondary or tertiary phenomena cannot be obtained, the history of the case must be sifted most carefully. In women, a history of miscarriage or of a series of still-births may be got. In hereditary syphilis, the eyes and teeth must be carefully examined. In young people, a corneo-iritis associated with sudden or progressive deafness, for which no cause can be discovered in the naso-pharynx or middle ear, warrants a diagnosis of labyrinthine syphilis. In older people, the liability to otosclerosis must be remembered, and the diagnosis must be carefully arrived at. But here, again, the history of a syphilitic infection often comes to the help of the practitioner in the formation of his opinion.

THE TREATMENT of syphilitic affections of the labyrinth is quite unsatisfactory, unless the case be seen in its very earliest stages. The treatment is that of the stage of the causative disease which is present at the time the deafness appears, *viz.*, mercury, either by the mouth or by inunction in the earlier stages, a continuation of mercury and iodide of potash in the later secondary, and earlier tertiary stages, and iodide of potash alone in the subsequent history of the case. Some authors believe *pilocarpine* to be of special value in the early stages of labyrinthine syphilis. It may be tried for one or two weeks, but must not displace for long the treatment proper to the condition.

Hyperæmia of the Labyrinth.—This condition scarcely merits

description as a separate disease. It occurs almost entirely as a symptom of some more general condition, in which the labyrinthine circulation has been disturbed. People of plethoric habit are most apt to have this, as they are to have other circulatory disturbances. Any sudden effort, or a violent fit of coughing, sends additional blood to the head and face, and the labyrinthine veins get over-distended. The abuse of alcohol has a similar effect. Acute inflammatory conditions of the middle ear, and even of the external auditory canal, are attended by a dilatation of the labyrinthine vessels. Cerebral congestions and inflammations act in the same way.

It is probable that the continued action of loud sounds, such as ultimately produce boilermaker's deafness, have as an early stage in the diseased process a hyperæmia of the labyrinth. Very loud sounds, such as explosions, heavy gun-firing, etc., produce an acute though temporary hyperæmia, or occasionally a labyrinthine bleeding. Unless the increased blood-pressure be very great, rupture will not take place; and unless the increased pressure be very long continued, tissue change will not result. Rupture will be predisposed to by previous disease of the walls of the vessels.

The disturbance of hearing caused by such drugs as quinine and the salicylates, is probably due in the first place to hyperæmia of the labyrinth.

THE SYMPTOMS of labyrinthine hyperæmia are a feeling of fullness in the ear, giddiness, and tinnitus. If rupture of the vessels occurs, all the symptoms of labyrinthine apoplexy result. If the pressure be long continued, even though slight, permanent deafness without much giddiness or tinnitus will result, *e.g.*, in boilermakers. Examination by the speculum displays nothing characteristic. There may be reddening of the tympanic membrane, and of the inner end of the external auditory canal. In the chronic cases, nothing is seen by the speculum, but, as in boilermaker's deafness, the upper tone limit is much lowered, and the bone-conduction for the tuning-fork on the mastoid process is shortened. In recent cases, where actual bleeding has not taken place, the symptoms,

though severe, soon pass away if the cause can be removed. In chronic cases permanent deafness will result, though the tinnitus and the giddiness may cease to give trouble. When bleeding has taken place, deafness is permanent and often total.

THE TREATMENT of labyrinthine hyperæmia is that of the causative disease. In rheumatic cases, where ear symptoms are present, such drugs as quinine and the salicylates should be avoided or used with great care. In plethoric individuals purgatives should be used, the use of alcohol interdicted, and the diet regulated to suit the general condition of which the ear symptoms are only a local evidence. If the symptoms be acute, local measures may be adopted. These consist of local blood-letting, the application of cold to the head or to the mastoid region, or the application of counter-irritants to the latter region or to the nape of the neck. Bromide of potash acts as a valuable sedative, and controls the tinnitus. Those who must be subjected to loud noises, should wear rubber sound-deadeners in the meatus (*Figs.* 28, 29, *p.* 85). In chronic cases, iodide of potash may be used with the object of promoting the absorption of any effused material, and pilocarpine, either by the mouth or hypodermically, with the same object.

Anæmia of the Labyrinth, like hyperæmia, is rather a symptom of a more general condition than a separate ear disease. It follows great hæmorrhages, such as that which sometimes attends child-birth, or it may be a consequence of a profound idiopathic anæmia.

THE SYMPTOMS of this condition are subjective noises, the rhythm of which is usually that of the cardiac pulsations, giddiness, especially on sudden movement of the head, and deafness, especially when the patient is amidst noisy surroundings. To these the symptoms and signs of general anæmia are added—paleness of the skin and mucous membranes, breathlessness on exertion, and great prostration. Hæmic murmurs in the neck are often discovered, and are of course synchronous with the tinnitus, like the cardiac impulses. Neither otoscopic examination, nor testing by tuning-fork, give any very characteristic evidence of the nature of the condition. There may be deafness, and if this is the case,

it is more marked in the higher parts of the scale. The bone conduction on the mastoid process is diminished. The general condition of the patient and the character of the tinnitus, give the best grounds for forming an opinion. The prognosis is good if the cause is not pernicious anæmia.

THE TREATMENT of anæmia of the labyrinth is the treatment of the general anæmia of which it forms a part, and the drugs found to be most useful are arsenic and iron. Quinine, except in very small doses, should be avoided. Strychnine has a good effect in many cases. The diet should be liberal.

Leukæmic Deafness.—In a certain number of cases of leukmiaæ, according to some authors about 10 per cent, well-marked aural symptoms appear—sudden or rapidly increasing deafness, sometimes with giddiness, tinnitus, and even vomiting and general collapse (Menière's symptom-complex). Post-mortem examination shows that these symptoms are due to an exudation of lymph cells, or to hæmorrhage within the labyrinth, and that in time organization of the effused material follows, with connective tissue formation and the occlusion of the lumen of the cochlea and semicircular canals by this connective tissue or by bone. In the severer cases, hearing is permanently lost, but in the slighter ones more or less improvement in hearing occurs.

Deafness in Mumps.—The records of deaf-mute institutions show that profound deafness occasionally follows mumps. No cases of mumps have been followed by severe deafness in the experience of the writer, though he has seen several cases in which no other cause could be discovered, and in which the concurrence of the deafness and that of an attack of parotitis seemed, from the history given, very probable. The deafness in these cases has been too profound to be due to any but an intra-labyrinthine cause.

Otalgia.—When pain is referred to the ear, and when neither otoscopic examination nor symptoms other than the pain point to a diseased condition of the organ of hearing, the condition is called *otalgia*. As a rule there is no deafness present. Such pain is usually either reflex in character, or it may be due to a true neuritis

of the nerves supplying the ear, such as those composing the tympanic plexus. Before describing a pain in the ear as otalgia, a thorough examination of the external ear, the external auditory canal, and the middle ear should be made. If no diseased condition of the canal be found (boil, exostosis, etc.), and if the membrane be normal in colour, curve, and lustre, attention must be directed to the structures round the ear. It is not uncommon for pain due to a rheumatoid arthritis of the articulation from the lower jaw, to be described as pain in the ear. Reflex otalgia is most commonly due to carious teeth. Ulceration within the mouth, at the root of the tongue, on the tonsil, or in the larynx, may be the cause of otalgia. Epithelioma of the tongue is often accompanied by pain in the ear in its later stages. Amongst general conditions attended by otalgia are rheumatism and rheumatoid arthritis (even when the articulation of the lower jaw is healthy), syphilis, and malaria. The pain of otalgia is usually intermittent, but when present it is very severe. It may be referred to the middle ear, or may be felt in the mastoid process—the latter more rarely.

The first indication for treatment is the removal of any cause of irritation, such as carious teeth, ulceration about the mouth and pharynx, or any cause found within the external auditory canal (foreign body, ceruminous collection, etc.) If syphilis be suspected, or if there be evidence of rheumatism, iodide of potash and the salicylates should be tried. If there be a history of ague, moderate or large doses of quinine should be given. If no such taint as any of the above be found, and if there be anæmia, iron and arsenic should be exhibited. If the pain be very severe it may be necessary to prescribe some local anodyne, such as liniments of belladonna or chloroform to be rubbed into the skin round the auricle, or a hypodermic injection of morphia may be given. In obstinate cases counter-irritants such as iodine or cantharides may be applied to the mastoid process.

Ear Trumpets and other Aids to Hearing.—It is too often the duty of the practitioner when dealing with ear disease, both in patients of advanced years and in middle life, to confess that he

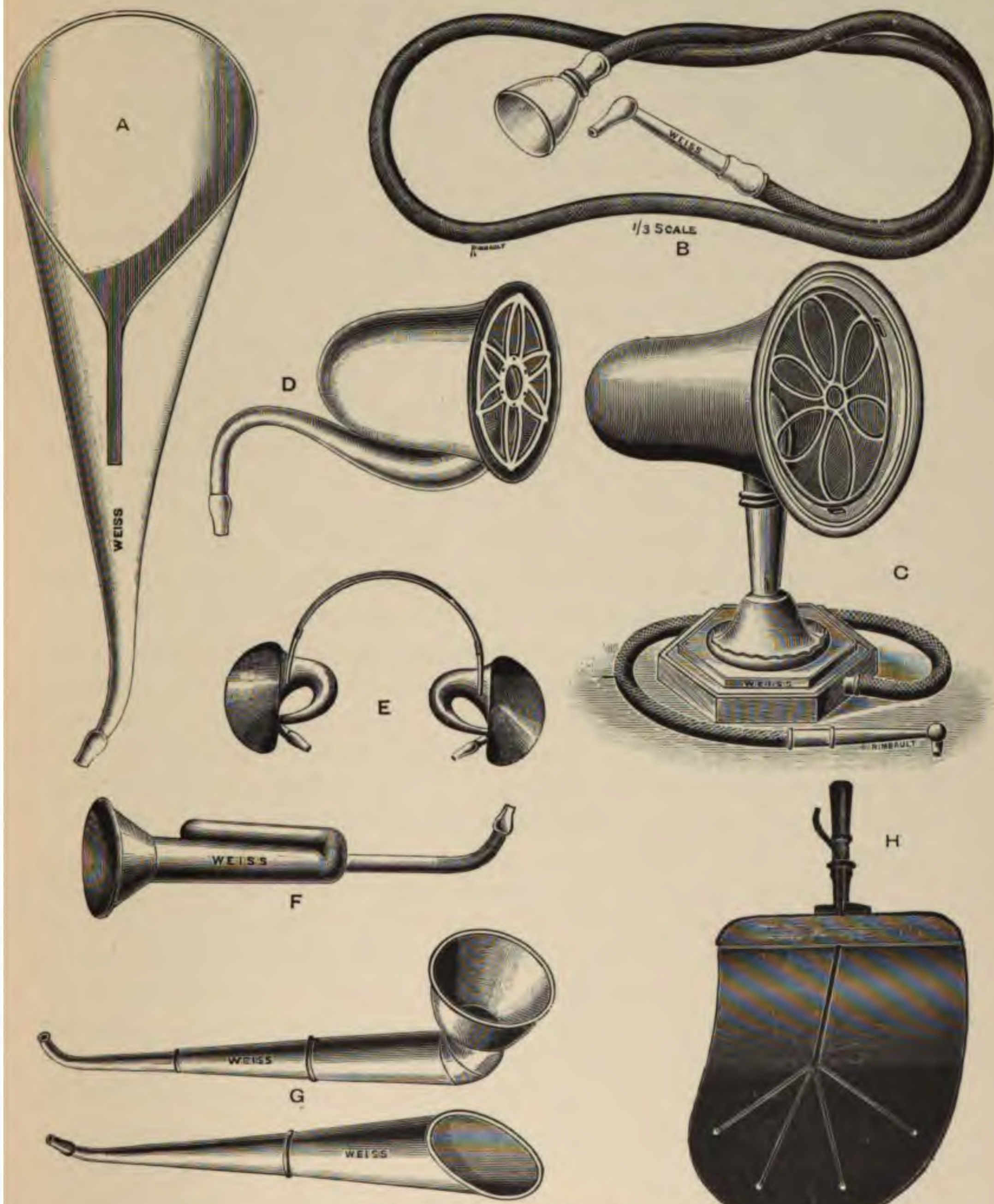


Fig. 58.—Aids to Hearing.

(A) Vulcanite Hearing Trumpet. (B) Conversation Tube. (C) Table Trumpet and Tube. (D) Nickel Hearing Trumpet. (E) Ear Cornet. (F) Japanned Trumpet. (G) Telescopic Trumpets. (H) Audiphone.

cannot hope to restore hearing, and to supply the sufferer with some form of ear-trumpet. On the whole, such appliances are not very satisfactory. Often they give no help at all, and even when they are of real assistance, the patient often rejects them because they are clumsy or conspicuous.

Most of these instruments are collectors and conductors of sound. Some are held by the hand to the ear with the bell-shaped collector directed towards the speaker (*Fig.* 58, *A*, *D*, *F*, *G*). Others are provided with a long tube, three or more feet long (*B*, *C*), the wider end of which is provided with a funnel-shaped receiver, which is held or placed by the speaker near his mouth, while the narrower vulcanite-tipped end is fixed by the deaf person in his meatus. One form of ear-trumpet fits both ears, and is fixed by a spring passing over the vertex (*E*).

Another form is represented by the audiphone or auditory fan (*H*), the free border of which is held between the incisor teeth of the deaf person, whilst the convex surface is directed to the speaker. The bones of the head act as the sound-conductor here, and appreciation for speech is sometimes greatly improved in this way, especially if the patient be a good lip reader. Artificial teeth interfere greatly with the result. It is in cases of chronic aural catarrh and otosclerosis that these aids to hearing give the best results. In the deafness of chronic middle-ear suppuration the artificial tympanic membrane gives a better result than the ear trumpet.

Electrical appliances advertised to make the deaf and even the deaf mute to hear have not established the claims put forward by their inventors and the manufacturing companies who advertise them. If those who face this problem would first study why the deaf, and especially the deaf mute, do not hear, much of the ingenuity displayed might be put to better purpose, and the public mind would not be disturbed by hopes which are certain to be disappointed.

CHAPTER XI.

DEAF-MUTISM.

Cause of Mutism in Deaf Children—Congenital and Acquired Deaf-Mutism—Etiology of Deaf-Mutism: (*a*) In Congenital Cases; (*b*) In Acquired Cases—Symptoms of Deaf-Mutism—The Objective Appearances of the Middle Ear in Deaf Mutes—The State of the Hearing in Deaf Mutes—Testing Deaf Mutes by a Continuous Tone Series—The Distribution of the Residual Hearing in Deaf Mutes and its possible Value in Teaching—The Morbid Anatomy of Deaf-Mutism—Prognosis in Deaf-Mutism—Treatment of Deaf-Mutism—The Education of the Deaf and Dumb.

WHEN a child is born deaf, or when very early in life he becomes deaf, speech is not developed as in hearing children, and deaf-mutism is the result. Speech, as ordinarily learnt and understood, depends on hearing. Exactly what amount of hearing must be present to allow of the development of speech, or on the other hand exactly what amount of hearing must be lost to endanger speech that has been recently acquired, it is not possible to state in figures. Roughly, it may be stated to be that amount of hearing which permits of the easy appreciation of conversational tones; and that stage of deafness which prevents the development of speech, or which causes the loss of recently-acquired speech, has been called by the writer "Surdism."

Deaf mutes are divided into *congenital* and *acquired*. The distinction is not strictly scientific, for the causes are often the same in the two classes of cases; nor is it always easily drawn, for deafness coming on in the early months of life may be put down as congenital, while congenital deafness may be put down to an illness happening in the early months of life; but it is practically useful, and no better classification has yet been offered.

canno ... ness be congenital or
some ... similarly placed child
not ... the effect of the absen
when ... who has become
becau ... because of the meni
M ... deaf-mutism, for the s
sound ... a result of meningitis
collect ... the disease. The wr
are pr ... ment of deaf mutes is a
wider ... this again is a res
which ... from two to seven years,
narrow ... much more active
meatus. ... activity expresses itse
a spring ... measurement. There is
Amo ... amongst the deaf and c
tan (H), ...
of the d ... heredity and causes
speaker. ... numbers of cases of dea
and appr ... in America, where epi
way, esp ... post-natal causes accou
teeth int ... genital.
amal catarr ... itary. It may appear in
best resul ... from parent to chi
the atten ... version to the charac
can ... themselves having perfect
... that any predecesso
... many cases occurring in
... the collateral branch
... an hereditary tend
... into the various br
... forty-two deaf m
... admissions have b
... and children are
... for the Deaf and D

Consanguinity in parents emphasizes family peculia offspring. Family defect and tendency to disease are p liable to become accentuated in this way. When an new feature or defect, such as deaf-mutism, appears ir it may be the expression of a latent character. Cons marriages produce deteriorated offspring; and deaf-muti etc., when they follow such marriages, may be the ex such deterioration. Amongst animals, when only perfect are used, in-breeding may be carried on to a very gr without visible bad effect. In the human race, where ev has some transmissible taint, consanguineous marriages immediately followed by deterioration. The marriages c genitally deaf and of the hearing members of fraterniti with congenital deafness, are much more fruitful of dea than the marriages of the hearing, or of the deaf whos has been acquired. Theoretically, the marriage of the co deaf should produce a larger number or proportion of dea than it seems to do. But certain checks are at work whic act the tendency :—

1. The marriages of the deaf, especially the congeni are less prolific than those of the hearing, and s common.

2. There is a tendency to reversion to the normal typ deaf mutes, as amongst all living beings.

3. Hereditary deafness is not always due to *one* state or defect. The deafness is common to two conger parents, but the immediate cause of the deafness may d thus, so that marriage does not necessarily accentuate th or deafness. Deafness in this connection is indeed a but nothing more. It no more implies one defect or d cough or jaundice does. The cough may be due to bronchitis, the jaundice to cancer of the liver, or gall s the deafness may in one parent be due to malformatio in the other to destruction by disease before birth (se Anatomy of Deaf-mutism ").

The commonest cause of acquired deaf-mutism is *meningitis*. Even in Great Britain, where epidemic cerebro-spinal meningitis is rare, this is true; in America and on the continent of Europe, where the epidemic form of the disease is common, the statement holds with greater force. Next to cerebral diseases, by far the commonest causes of acquired surdism are *scarlet fever* and *measles*. If these two diseases be taken together, they cause in Britain more deaf-mutism than cerebral affections. Scarlet fever alone causes three times as many cases as measles. Taken together, cerebral affections (meningitis) and scarlet fever and measles, cause nearly 60 per cent of acquired deaf-mutism in Britain. Next to these causes in order of importance, come two classes of about equal magnitude: falls and injuries to the head; and other fevers, such as enteric, typhus fever, etc. Falls and injuries to the head are often blamed for deafness which is really congenital, so that this class appears exaggerated in the statistics. Whooping cough accounts for a small number of cases. These definite causes make up about 75 per cent of our cases of acquired deaf-mutism, the other 25 per cent being divided amongst causes which either operate very rarely or are very indefinite. (*See Table, page* 294.)

A remarkable feature coming out in the study of this subject, is the *rarity* with which primary ear disease causes deaf-mutism. In young children suppurative ear disease is often tuberculous, and as we have seen, causes great damage to the middle ear, mastoid process, and even to the brain and internal ear; but it is to the rarity with which the internal ear is attacked, and to the fact that even when it is damaged, the mischief is unilateral, that we owe the insignificance of primary ear disease as a cause of acquired deaf-mutism.

There is no doubt that hereditary syphilis is a definite and not uncommon cause of both acquired and congenital deaf-mutism. Some observers (Dalby, etc.), think it is a very common cause of the condition. Amongst 127 children at the Glasgow Institution, three cases of typically syphilitic teeth were found. On the other hand, the occurrence of sudden deafness in young people who have

[illegible] suggests that even earlier in life, before [illegible] been acquired, syphilis may destroy the [illegible] deafness.

TABLE I.

[illegible]	Scarlet Fever.	Measles.	Enteric and other Fevers.	Whooping Cough.	Syphilis.	Primary Ear Disease.	Disease and Illness.	Miscellaneous Causes.	Unknown Causes.	Total.
[illegible]	5	5	1	—	—	—	2	10	—	35
[illegible]	5	6	6	—	—	—	—	8	10	55
[illegible]	4	2	3	—	—	3	—	8	9	36
[illegible]	14	4	—	—	—	—	—	4	—	24
[illegible]	33	9	13	2	—	—	—	5	3	153
[illegible]	112	30	3	8	—	—	—	16	3	267
[illegible]	5	1	1	—	—	—	—	2	2	15
[illegible]	[illegible]	26	58	10	—	1	—	40	—	278
[illegible]	[illegible]	[illegible]	—	2	—	—	—	3	9	46
[illegible]	[illegible]	[illegible]	4	6	—	2	13	5	—	92
[illegible]	[illegible]	[illegible]	17	1	—	—	5	20	—	124
[illegible]	[illegible]	[illegible]	3	2	—	—	4	1	—	29
[illegible]	[illegible]	[illegible]	5	—	—	—	6	7	14	83
[illegible]	[illegible]	[illegible]	5	2	2	12	7	13	31	173
[illegible]	[illegible]	[illegible]	[illegible]	33	2	18	37	175	98	1410

[illegible] compiled by the author from figures [illegible] masters of British institutions. The [illegible] columns are unsatisfactory, or at [illegible] but greater precision was not [illegible]

SYMPTOMS.—The *physiognomy* of the deaf mute is not peculiar. If he is not idiotic—and not more than two or three per cent of deaf mutes are so—he is as bright and intelligent-looking as a hearing child. Children who are "backward" are common amongst the deaf, and are commoner amongst those whose deafness is acquired, than amongst the congenitally deaf. This is because in the former, the causative disease—oftenest meningitis—has damaged the brain as well as the ear. But this backwardness or slowness does not cause any special physiognomy, it is only discovered by the teachers when education has begun. The lack of power to acquire language in some congenitally deaf children who have a good deal of hearing, is probably due to developmental defect.

The *breathing* of the deaf mute is peculiar. It is loud, noisy, and less under control than in hearing children. This is due to the fact that it is not heard by the deaf mute, and consequently no attempt is made to control its rhythm; and also to the fact that post-nasal adenoids are very common amongst the deaf, and give rise to breathing which is noisy, and which, as in the hearing, causes a special physiognomy.

The smaller head-measurement of deaf mutes has been noticed, and an explanation of it offered; but this character can only be applied as a test to deaf mutes as a class, and not to individual cases. Microcephalous cases are not common amongst the deaf. When they occur, the children are more or less imbecile.

Eye affections (chiefly corneal), post-nasal adenoids, tuberculous enlargements of glands, etc., occur amongst deaf mutes very commonly, but these are due to the constitutional conditions which are present, and which may or may not have caused the deafness. The symptoms caused by them are not peculiar to deaf mutes, although the deafness may have to be taken along with the other symptoms, and both traced to a common cause, *e.g.*, syphilis, tuberculosis, etc.

Giddiness is seldom complained of by deaf mutes, and noises in the ear appear to be rare. When rotated for a time about an axis, to an extent which generally produces great giddiness and

unsteadiness of gait in hearing people, most deaf mutes experience no giddiness, and are able to walk at once in a straight line. James and Kreidl, who called attention to this, attribute the immunity from giddiness here described, to destruction of the semicircular canals in these cases, and the inference seems a fair one.

The Examination of the Ears of Deaf Mutes divides itself into the information got : I.—By ordinary otoscopic examination, and by the examination of the naso-pharynx ; and II.—By testing the hearing.

I.—*Otoscopic examination.*—The results of this kind of examination are well illustrated in the following table, which shows the condition of the ears in 175 cases examined at the Glasgow Institution.

TABLE II.

	Acquired Deafness.	Congenital Deafness.	Doubtful.	Total.
Membranes normal (both)	28	26	7	61
Suppurative Otitis Media (active or extinct) ...	18	11	3	32
Changes indicating non-suppurative Catarrh ...	34	33	11	78
Unexamined	1	—	1	2
Meatus too narrow for examination	—	2	—	2
	81	72	22	175

Thirty-seven of the above had their ears plugged with ceruminous masses and foreign bodies, such as pebbles, pieces of wood, bits of cotton-wool, beads, etc. The following are the chief facts brought to light by the otoscopic examination of the ear, and by examination of the throat and naso-pharynx in deaf mutes.

1. Many deaf mutes (from 30 to 50 per cent), have one or both tympanic membranes normal.

2. Many also show changes in the membrane—alterations in curve, lustre, transparency, thickness—similar to those found in hearing individuals, and which are not as a rule responsible for the deafness. These changes are for the most part due to the presence of enlarged tonsils and post-nasal adenoids, the latter of which are very common amongst deaf mutes—probably to the extent of 60 to 70 per cent.

3. A minority—at least 10 per cent—show evidence of past or present suppurative disease of the middle ear. These occur amongst both congenital and acquired cases, but are found chiefly amongst those acquired cases due to scarlet fever and measles.

4. Examination by speculum discovers no lesion, characteristic of acquired, as distinguished from congenital deafness. Discoverable lesions are commoner amongst the former than the latter, but many of the changes occur subsequently to the onset of deafness, the anatomical cause of which lies deeper than those parts which can be subjected to examination by mirror and speculum.

The information got by otoscopic examination does not by itself, as a rule, define the immediate cause of the deafness in deaf-mutism, and is not for this purpose comparable with *post-mortem* examination; but taken along with the history of the case, and the state of the hearing, it is often very important. On the other hand, it is of great practical importance in the treatment of the ear diseases of the deaf and dumb. The facts, that suppurative conditions are so common, and that tuberculous disease accounts for some of these suppurative conditions, render the discovery and treatment of active ear disease in the deaf mute imperative, both in the interests of the patient and of his associates. Further, these suppurative conditions sometimes give rise to attacks of acute mastoiditis, and to brain affections necessitating operation. During the year ending July, 1903, the radical operation for acute symptoms had to be done by the writer at the Glasgow Institution for the Deaf and Dumb, in four deaf mutes.

II.—*Testing the Hearing in Deaf Mutes.*—Watches, acoumeters, whispered speech, and in most cases speech in conversational tones, are useless in the discovery of the remains of hearing in the deaf and dumb. Were this not so, deafness would not involve mutism. The clapping of hands, the ringing of bells, the loud shouting of vowels, and sometimes of consonants, elicit evidence of hearing from many deaf mutes. Stamping on the floor is a fallacious test; for appreciation of the molecular disturbance transmitted to the body and the bones of the head is no evidence of hearing. Whatever the tests used, they must be applied under the following conditions.

Fig. 60.—Bell for Testing Hearing in Deaf Mutes.

When *the voice* is used as a test, the ears must be tested separately, and precautions must be taken against lip-reading. All very deaf people lip-read to some extent, and some, even the untaught, lip-read to a very great extent. The test words or vowels should be pronounced either behind the child's back, or his eyes should be covered by the surgeon's hand. For the practical purposes of the teacher, testing by the voice is by far the most valuable method. If a child cannot hear the sounds of the voice, it does not much matter what he hears above or below in the musical scale.

For the demonstration of the presence of aerial hearing, the writer has found a *large bell* the best instrument (*Fig.* 60). The blindfolded child is made to count the strokes, delivered singly or at short intervals. The appliance used is a large dinner bell, with a spring tongue attached at the junction of the handle with the bell, and so arranged that a violent shake produces a sound of great intensity. In the open air this bell can be heard at a distance of

over 1,000 yards. Such a bell is not only capable of emitting very loud sounds, but being rich in overtones, represents a very large part of the musical scale.

A single large *tuning-fork* may be used for testing for the presence of hearing in deaf mutes. It may be used either in the air or on the mastoid. Although the fork thus used brings out in a few cases evidences of hearing which have not been discovered by the voice, its use is very limited, because it represents only one tone without overtones, and because it requires a very intelligent deaf mute to appreciate the conditions of the experiment. On the mastoid, *tremor* is apt to be taken for *sound*. But for mapping out areas of hearing in the ears of deaf mutes, it will be seen that the tuning-fork is of special value.

By the application of the above tests for the presence of hearing, deaf mutes may be divided into the following classes.

1. The stone deaf—hearing neither the bell nor the loudest shouting, nor the tuning-fork sounded in the air.

2. Those who hear, and more or less distinguish, the loudest sounds, *e.g.*, the voice from the bell.

3. Those who hear and distinguish the sounds of the human voice.

The stone deaf form 10 to 20 per cent of deaf mutes; class 2, about 60 per cent; and class 3, the semi-deaf, about 25 per cent. These results are based on the examination of 123 deaf-mute children, all having one or more year's tuition. The testing of the uneducated deaf mute as he enters the Institution is fallacious; he does not understand the nature of the test which is being applied to him.

Distribution of the Residual Hearing in Deaf Mutes.—The above classification of deaf mutes on the basis of remaining hearing power, and the tests described, are sufficient for most practical purposes; but a more exhaustive examination of the distribution of the residual hearing is of great interest, and sometimes of practical value.

The following cases show the distribution of the residual hearing

in 33 deaf-mute children, some of whom have been born deaf, while others have lost their hearing since birth. The *tests* used were Bezold's continuous tone series, made by Edelmann, of Munich. This series consists of fourteen tuning forks, two whistles or pipes, the pitch of which can be varied by means of a movable stopper, and the modification of Galton's whistle, made by Edelmann (*See Figs.* 23, 24, 25; *pp.* 70, 74, 75). The pitch of the forks is varied by movable clamps. The whole series supplies tests ranging from 16 vibrations per second to over 50,000 vibrations. The time needed for testing one child is about an hour and a half. It is possible to examine two or even three children at one time, but this means additional precaution to ensure accuracy, and prolongs the period of examination.

The ears were tested separately, the ear not under examination being stopped thoroughly by a finger. The forks were struck and the whistle made to sound behind the child being tested; and control tests in which no sound is produced were used to make sure that the answers were reliable. An experienced teacher, usually Mr. Addison (the Principal of the Deaf and Dumb Institution, Glasgow), was seated before the children, to interpret their appreciation for the tests used.

CASE I.—ALEX. McD., *æt.* 16.—*Born deaf.* Both tympanic membranes are somewhat retracted and dull, and the left tonsil is enlarged.

In the right ear there is a continuous hearing island from a to a^5, and in the left two islands from e^1 to g^3 and from c^4 to a^4. Hears but does no distinguish vowels. Has no speech.

CASE II.—ROBERT McL., *æt.* 17.—*Born deaf, and has two deaf-mu brothers.* Both tympanic membranes retracted, the right chiefly above tl short process of the malleus, and the left in the membrana tensa, so that t malleus handle is indrawn.

In this case there is a single hearing island in the right ear, extending fr about e^4 to g^5, fully an octave. On left side a series of hearing islands exi The lowest is from e^1 to g^2, then there is a gap till c^3 is heard, then another of nearly two octaves to g^4, between which and d^5 three small islands of hea exist. Has no hearing for speech, and no speech.

CASE III.—LIZZIE C., *æt.* 16.—*Said to have been born hearing, b*

have become deaf at one year because of a fall which happened then. (It is of course quite possible she was born deaf, and the fall put down as the cause of deafness—only discovered at a later date—say when speech did not develop). Both tympanic membranes are retracted but quite intact. Throat normal.

The chief hearing island on the right ear begins very low, D_{1}, 35 vibrations, and extends to c^{2}, or nearly four octaves, then after a short gap there is a small island from f^{2} to g. On the left side the islands B to e^{3}, and then a single note at b^{2}. Has no hearing for voice. She has some, but little speech, though her voice is fairly well intoned.

CASE IV.—JESSIE S., *æt.* 15.—*Born deaf, and with three deaf-mute brothers in the Institution.* Both tympanic membranes are retracted, but intact, and the tonsils are somewhat enlarged.

There is a single hearing island from B to g^{3} on the right side, and on the left side an island of nearly an octave from g^{1} to a^{2}, a single note heard at c^{4}, and a rather doubtful island from g^{4} to b^{4}. Distinguishes the vowels *a* and *o*, but not consonants. She reads easy sentences, and the voice is fairly well intoned.

CASE V.—CHRISSIE MCI., *æt.* 15—*Born deaf.* Both tympanic membranes retracted, but the throat is normal.

The hearing islands are very small. On the right side there are two, one from g^{3} to e^{3} and a small one from f^{4} to g^{4}. On the left side there is only one, also from f^{4} to g^{4}. She has a fair amount of speech, and the intonation is fair. She has no hearing for voice.

CASE VI.—SAMUEL G., *æt.* 17.—*Born hearing.* (Again the cause of deafness said to have been a fall downstairs. But as this happened at four years, there is no reason to doubt that the boy was born hearing). Both tympanic membranes are intact, though perhaps retracted, and the throat is normal.

There are two small hearing islands in the right ear, the lower from c^{3} to g^{3}, another from f to c^{5}. No scrap of hearing could be discovered in the left ear. He has no hearing for voice. He reads fairly well, but as his voice is breaking, its intonation cannot be judged of.

CASE VII.—MCF., *æt.* 17.—*Born deaf. This boy is nearly blind, he has an old iritis, a very small head, and the appearance of being deficient intellectually.* Membrane normal in both ears.

He hears lower notes than any deaf mute amongst the thirty-three examined, *viz.*, G_{2} = 24 vibrations. In the right ear an island extends from G_{2} to G, and another from e^{2} to e^{6}, on the left an island begins at G_{2} and extends to D, then G is heard as a single note, then there is no hearing till we come to d^{3}, where an island starts which extends to a^{3}. He has not hearing for voice, nor speech.

CASE VIII.—JAMES L., *æt.* 16.—*Born hearing.* In this case there is facial palsy on the right side, some discharge with perforation of the right

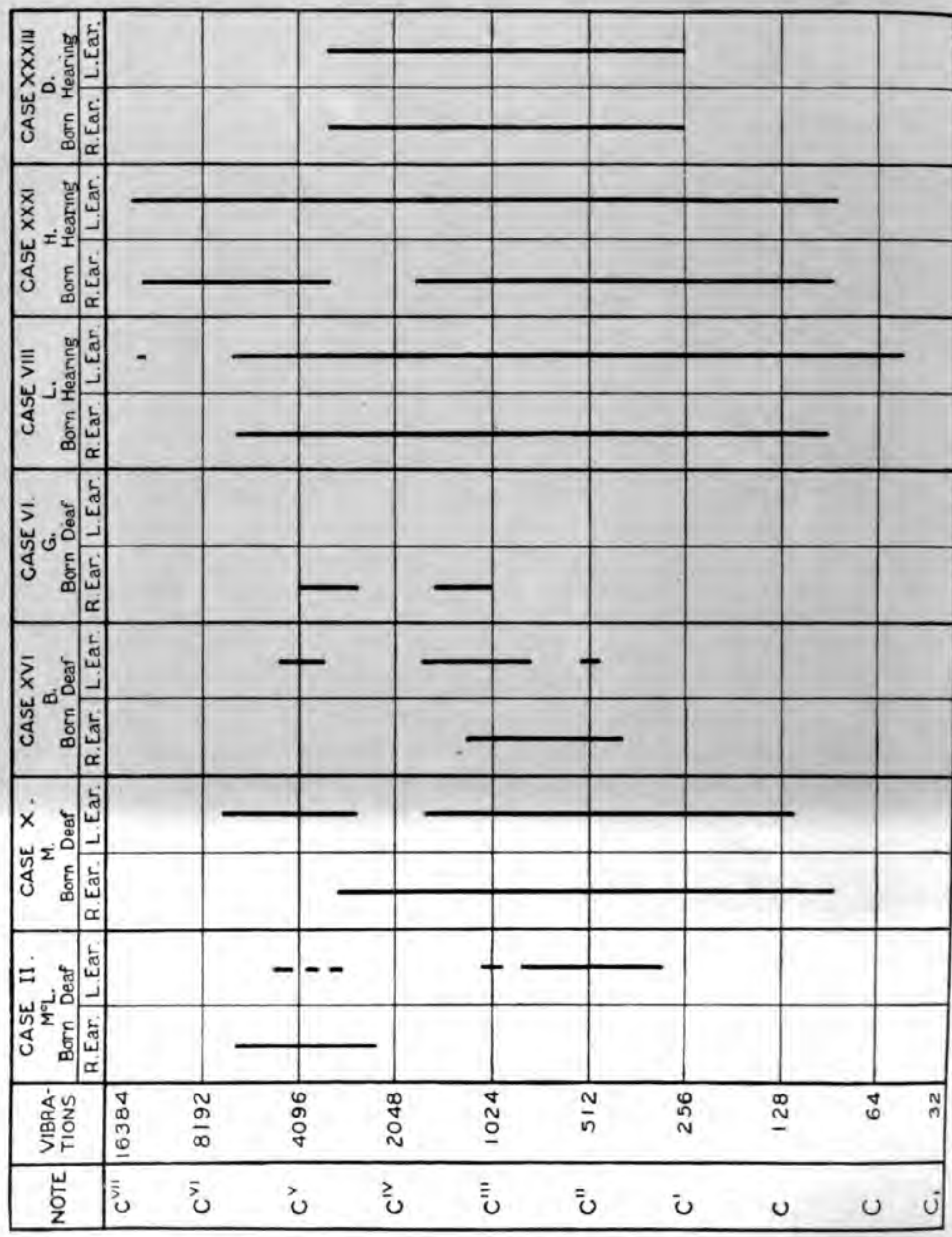


Fig. 61.—Specimen Chart of Hearing Islands in congenital and acquired Deaf-Mutism.

tympanic membrane. There is a mastoid operation fistula behind the left ear, and there is no tympanic membrane on this side. There are strumous scars on the right side of the neck.

He has a very large hearing island in the right ear extending from G to a^5, and in the left a still larger one extending from A_1 to a^5, then a gap to g^6, which is heard as an individual note. This boy hears all the vowels, some of the consonants, but cannot distinguish sentences. He does not use his voice in speech.

CASE IX.—ALEX. M., *æt.* 16.—*Born deaf.* The tympanic membranes are normal on both sides.

On the right side there is only one hearing island, d^3 to a^3. On the left side there are two, the lower from g^2 to a^3, and then d^4 is heard as an isolated note. There is no hearing for the voice, and no speech.

CASE X.—ALEX. M., *æt.* 14.—*Born deaf.* Both tympanic membranes and the throat are normal.

There is one hearing island on the right side, extending from G to a^4. In the left ear there are two islands; the lower begins at B and extends to a^3, the higher from f to a^5. Distinguishes the vowel *a*, but no consonants or sentences. He articulates fairly well, and the intonation of his voice is good.

CASE XI.—JAMES G., *æt.* 14.—*Born hearing, became deaf at four years, from measles.* On both sides most of the tympanic membrane is gone. The throat is normal.

On the right side hearing has been almost entirely destroyed, the notes g^1 and c^4 being heard as small islands, but nothing else being heard. . On the left side, three large islands of hearing have been left with short gaps between. The lowest island extends from G to c^2, the second from c^3 to a^5, and the third from d^6 to d^7. This boy has no hearing for voice, but he reads with fair distinctness, and the intonation of his voice is very fair. He is described by the teachers as a semi-mute.

CASE XII.—MARTHA S.. *æt.* 12.—*Said to have been born hearing, but to have lost hearing at seventeen months.* This is just when a child begins to speak, and when congenital deafness is often first discovered. That the cause of deafness is congenital, is supported by the facts that the middle ear and the throat are normal, and that the hearing islands are exactly alike in both ears.

These extend from c^3 to a^5, one on each side. Distinguishes the vowels *a* and *o*, but neither consonants nor sentences. Her reading is said to be good, and the intonation to be very good.

CASE XIII.—CHRISSIE MCL., *æt.* 14.—*Born deaf. There are two others in this family deaf and dumb, and at present in the Institution.* Both tympanic membranes are normal, and the tonsils are slightly enlarged.

On the right side the hearing islands are extensive, reaching from A_1 to a^3, with the exception of a single note g^2 which cannot be heard, then there is a

CASE XIX, DONALD MCA., *æt.* 14.—*Born deaf, and has two deaf-mute sisters in the Institution.* Both tympanic membranes are normal.

There is only one hearing island in each ear, a larger one on the right side, and a very small one on the left side. The right island extends from G to c^2, and the left one from *e* to *a*. It is doubtful if there is any hearing for voice. The amount of speech is small, and the intonation poor.

CASE XX, A. Y., *æt.* 14.—*Said to have lost hearing at ten months from meningitis.* The left tympanic membrane is reddened, and there is a depression in Shrapnell's membrane suggestive of an old perforation; the left membrane is normal, the tonsils are enlarged.

There is only one small island on the right side, extending from g^2 to d^3, and two on the left, the lower from g^2 to c^3, and the upper from g^3 to b^4. There is no hearing for voice. The reading is poor, the voice is high and squeaky, and the intonation poor.

CASE XXI, ROBERT MCN., *æt.* 13.—*Brother and father's uncle both deaf mutes.* Both tympanic membranes are normal, and the tonsils are enlarged.

There are two hearing islands on the right side, the lower one from *G* to *g*, and the upper consisting of a single note only, c^3. No hearing could be discovered in the left ear, except a small island at c^3. There is no hearing for the voice. The reading and the intonation are fair.

CASE XXII, GEORGE G., *æt.* 15.—*Born hearing.* The right membrane is normal. The left ear was affected by chronic suppurative inflammation, during the course of which an acute mastoiditis developed, and the radical mastoid operation was performed in the Institution.

On the right side there is a very long island extending from *D* to d^3. In the left ear no hearing could be discovered. There is no hearing for voice, the reading is poor, and the intonation poor.

CASE XXIII, BESSIE H., *æt.* 13.—*Born hearing. Lost hearing from scarlet fever at three years.* Right membrane retracted and dull, and with perforation in the antero-inferior quadrant. Left membrane retracted and dull, with a scar in antero-superior quadrant. Tonsils nearly normal.

There is a single hearing island on the right side from c^3 to a^5, on the left side two islands from *D* to a^3, and the upper g^4 to c^5. All the vowels are distinguished, and the "explosives" among the consonants, but no sentences. She reads moderately well, and the intonation is very fair.

CASE XXIV, AGNES C.—*Born deaf. Has a sister (in the Institution) a deaf mute, and an imbecile cousin.* Both tympanic membranes are normal, and the tonsils are pretty large.

There is a hearing island on the right extending from c^3 to *b* , and on the left side a nearly parallel island from c^3 to a^3, and below this is an island

CASE XXXI, WILLIAM H., *æt.* 12.—*Born deaf.* There is a scrofulous scar in the neck. Both tympanic membranes are normal. The tonsils and pharynx are somewhat thickened.

There are two extensive hearing islands on the right side, the lower one from G to a^8, and the upper one from g^4 to g. On the left side there is one long island extending from G to a^6. In this case all the vowels are distinguished, most of the consonants, and many monosyllables. The reading is very good, and the intonation very good.

CASE XXXII, JAMES M., *æt.* 13.—*Born hearing. Deafness said to be due to scarlet fever at two years.* The right membrane is normal, the left has traces of old suppuration, but though scarred, is now intact.

There are two hearing islands on the right side, the lower one extending from G to g^5, and the upper one from c^6 to a^6. On the left side there are two smaller islands, the lower one extending from G to a^1, and the upper one from a^3 to c^4. In this case all the vowels are distinguished, also some of the consonants, and some sentences. The reading is very good, and the intonation very good.

CASE XXXIII, HECTOR D., *æt.* 12.—*Had suppuration of the ears before time of speaking.* Has hazy corneæ. Has discharge from right ear, and a perforation in the right membrane, in great part destroying it. The left membrane is for the most part gone, and adherent in its remaining parts to the internal tympanic wall. The throat is a little thickened, and he has a nasal catarrh.

There are two co-extensive hearing islands, one in each ear, their limits being from c^1 to a. All the vowels are heard and distinguished, as well as some of the consonants, and some simple sentences. The reading is good, and the intonation good.

These pupils were selected on a very simple plan. Mr. Addison began at the top of the school, and came downwards, till thirty children had been tested. He then suggested that he might bring two or three cases of special interest, because he knew they possessed a good deal of hearing. The ages of the children are from 12 to 17 years, with the exception of one who is only 10 years. Examples of these hearing islands have been put in a chart (*see p.* 302).

The chief points which emerge from a study of these cases are:—

1. None of the cases of *acquired* deafness has any deaf-mute relative.

2. Amongst the *deaf-born* cases there are 16 deaf-mute relatives,

or an average of one each, and these are nearly all closely related to the child in each case.

3. None of the cases of children born deaf has *total* absence of hearing. An island (or islands) of hearing is present in every ear.

4. Amongst 15 acquired cases, there are 6 quite deaf on both sides, and 2 quite deaf on one side, so that of 30 ears there are 14 in which not a vestige of hearing exists.

5. When the hearing islands in 15 congenital cases are added as they occur in the chart, a total of 70 inches is got. When the hearing islands of 15 acquired cases are added, a total of 65 inches is got. But as 14 of the 30 ears have no islands at all in the acquired cases, it would seem that where islands do exist in acquired cases, they are on an average much larger than in congenital ones; in the above cases nearly twice as long. In none of the congenital cases does otoscopic examination discover any gross destructive lesion of the middle ear, such as large perforation, or loss of ossicles. In 12 of the 15 acquired cases there is either loss of the whole or part of the tympanic membrane and ossicles, or scars of perforation which have healed.

Morbid Anatomy of Deaf-mutism.—The objective examination of the ears of deaf mutes shows that every part of the hearing organ which can be inspected during life, may appear normal in a case of total deafness. The converse statement, that every part which can be so inspected may appear abnormal consistently with good hearing, is a truth known to every aural surgeon.

Writers on deaf-mutism have spent much time in bringing together all the *post-mortem* examinations which have been made of the temporal bones of deaf mutes. Many of these examinations are incomplete, not having extended to the inner ear at all; in many the microscope has never been used; the number in which a clear clinical history together with a careful examination of every part of the ear and of the auditory nerve and brain is accessible, is still small. Pathologically, the distinction between congenital and acquired deaf-mutism breaks down. Clinically, it is convenient, but with the exception of the small number of cases due to malformation

on the one hand, and to the equally small number due to recent suppurative changes on the other, the morbid appearances found in the ears of deaf mutes show nothing characteristic as between congenital and acquired cases. Often, unless helped by a clinical history, we should be unable at a given autopsy to say whether the deafness was congenital or acquired. The results of the most careful *post-mortem* examinations show :—

1. That acquired deafness is usually due to disease of the internal ear, which has spread by the middle ear, and caused inflammatory changes involving destruction of the membranous labyrinth and of the nerve structures which it supports; the labyrinth in these cases may be destroyed either in whole or in parts. In a smaller number of cases the attack has been delivered from the side of the brain; and more rarely still, the damage to the inner ear is due to a primary labyrinthitis.

2. In congenital cases, the changes on which the deafness depends are not essentially different from those described above, except in the cases which depend on arrest of development or malformation. They consist in obliteration of the normal nervous structures by inflammatory new formations—chiefly osseous. It is not possible to estimate the proportion of cases due to malformation, but it is undoubtedly smaller than was formerly supposed. After a series of years, it cannot be decided whether a given structure has never existed, or has been obliterated.

PROGNOSIS IN DEAF-MUTISM.—With regard to life, the prognosis is good; with regard to hearing, bad. Within the Institutions the death-rate amongst deaf-mute children is as low or lower than amongst the better-to-do classes of the cities in which these institutions are placed. This is due to the excellent hygienic arrangements which prevail in these establishments which, as we have seen, produce physical conditions in the deaf mute of the best kind. When these children leave the Institutions, they become handicapped in the struggle for existence. Derived as they are for the most part from the poorer classes, and being further handicapped by their defect, they die in larger proportion than hearing people, of

those diseases the predisposing causes to which are bad fee poor housing, and insanitary conditions generally. For the reason, they do not compare favourably with hearing people i matter of longevity. Deaf mutes with chronic suppuration w the temporal bone, are liable to the special risks which attend condition in hearing people, *viz.*, mastoiditis and intra-cı complications.

With regard to hearing, the prognosis in deaf-mutism is bad. The causative disease takes place in very early childho is congenital, and probably always involves the internal ear. nasal conditions may contribute to the deafness, but are ne chief cause. Politzer narrates a case in which hearing dev between the third and sixth year; and the writer has descr case in which hearing developed somewhat between the ages c and twelve years, when the removal of post-nasal adenoid followed by further improvement in hearing and speech. W speech will survive the loss of hearing, depends on various fa the extent of the loss, the age of the child when hearing is and the efforts which are made to keep up speech after he is lost. Generally, if total deafness occurs before seven or years of age, dumbness results.

TREATMENT OF DEAF-MUTISM.

Except in those cases in which there is active middle-ear dis or in which the naso-pharynx or the pharynx is diseased, treatment is useless. Enlarged tonsils and adenoid vegeta should be removed, if they are well marked, for the general h of the child will benefit in this way, and his articulation wi much better than if these cavities are left untouched. If the hi of the case warrant the opinion that the deafness is to any e of middle-ear origin, inflation by Politzer's method should be to follow, for a period of several weeks, the operative treat in the naso-pharynx. Suppurative disease in the middle ear sl be treated in the ordinary way, and carried out till all disc from the middle ear cease.

t may be attempted in the way of dealing with the residual and speech of the deaf, will be discussed under the next of "Education." Attached to every institution for af and dumb should be a competent aurist, whose duties be:—

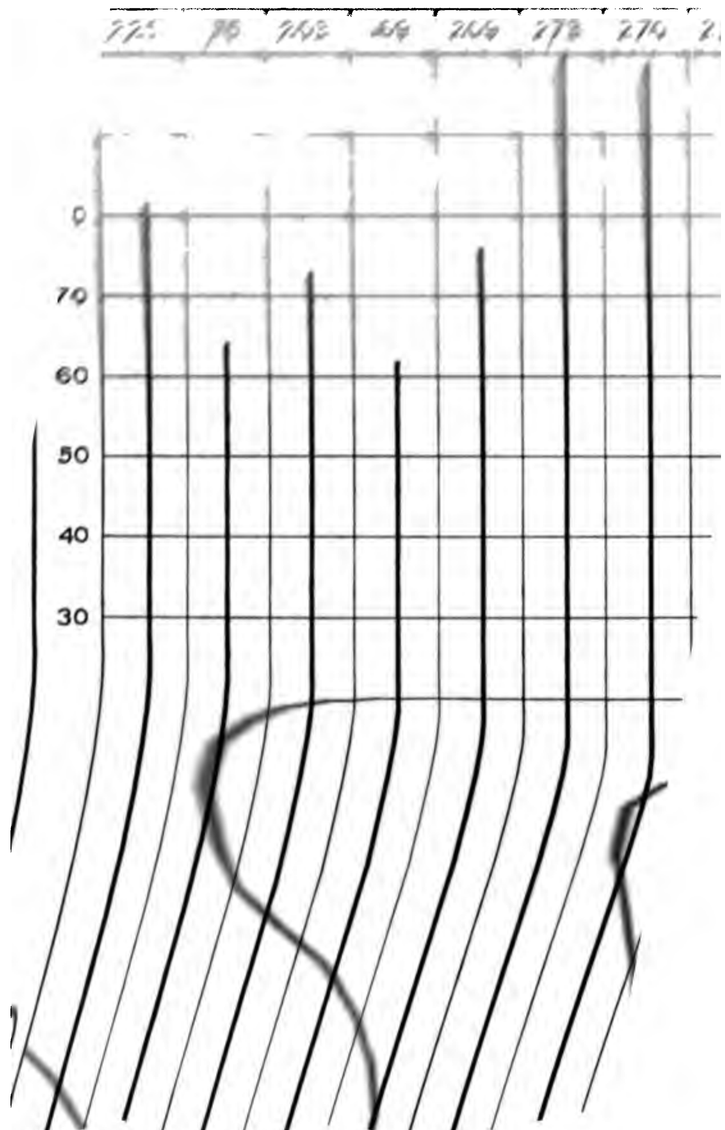
. To examine all new pupils admitted with regard to the nce of remains of hearing, and in conjunction with the teachers, ecide upon the best method of education for the individual child.

2. To treat suppurative ear conditions till healing and sation of discharge be attained. The examination on admission ll discover foreign bodies and ceruminous collections in the external iditory canal, also middle-ear affections and naso-pharyngeal ffections; but testing the hearing, except in the semi-deaf, hould be postponed till the end of the first session at school, as the pupils on admission cannot appreciate the nature of the test.

EDUCATION OF THE DEAF AND DUMB.

It has been said that the education of the deaf and dumb is a subject for pedagogues, and that otologists should leave it severely alone. With this opinion the writer has never been able to fall in. Not only is the deaf child seldom quite deaf, but deaf children so vary in other respects, *e.g.*, with regard to eyesight, general intelligence, etc., that it is impossible to regard them as all equally fitted for any one method of treatment; and so to classify them that the best shall be made of them all, requires the study of the otologist, as well as that of the teacher.

Two great methods of educating the deaf are in use at the present day: the silent method, and the oral method. The *silent method* is based on writing as its chief means of expressing the thoughts of the deaf person, and when writing is not available, the silent method substitutes signs and the finger alphabet. The *oral method* trains the eye to take the place of the ear in appreciating speech. The deaf person follows the movements of the lips and tongue of the speaker so closely that he is more or less successful in discovering what that speaker says; and although he himself hears


0
70
60
50
40
30

to teach by the auditory nerve. The percentage is calculated by the time during which a fork is heard by the deaf child, compared with that during which the same fork is heard by a healthy ear. Something must depend on the intelligence of the child, but with less than 10 per cent of hearing it is not worth carrying on the education of even an intelligent child by the auditory nerve. Even with this amount of hearing, in an intelligent child, teaching by the auditory nerve alone will be wholly insufficient.

Fig. 63.

Bezold has suggested, and Köller carries out, a combination of the acoustic and oral methods, which seems destined to take a permanent place in educating the deaf. No hearing trumpets of any kind are used, but the teacher speaks loudly into the child's ear, whilst the latter watches the movements of the former's lips in a mirror held in his own hand (*see Fig.* 63). Thus the eye and

ıe ear are both engaged in deciphering what the speaker says, nd it often happens that where the eye fails the ear succeeds, and ice *versa*. At Munich, about 20 per cent of the pupils are trained n this method, and their speech is very good; much better than hat of the corresponding pupils who have no hearing, but who are rained on the oral method.

The use of the mirror in teaching articulation and lip-reading s not new. It was introduced by Hill, a German teacher, about he middle of last century, and is in use in many German and British chools; but the combination, as above described, in oro-acoustic exercises, is new.

Another application of the oro-acoustic method of training the semi-deaf is that associated with the name of Urbantschitsch of Vienna. This otologist tests the hearing of deaf mutes by a "harmonica" or concertina, which can be made to emit strong sounds of short duration, or weaker sounds of longer duration, the range being from the lower notes of the musical scale to the higher notes used in music (about five octaves). As an accurate test of the limits of residual hearing the harmonica is inferior to the continuous tone series of Bezold, for the harmonica is rich in upper partials; but as a practical test of the presence of hearing for certain notes, the harmonica is of use. Having discovered the presence of hearing by the harmonica, Urbantschitsch tests the deaf child with vowels and consonants, and if these tests are positive, with words and sentences. A series of graduated hearing exercises is then used for the semi-deaf, which according to this author results in a development of hearing power, and which, whether this view be accepted or not, results, like all acoustic training when combined with oral training, in a greatly improved articulation on the part of the semi-deaf.

The writer has seen Urbantschitsch demonstrate his method, and has watched its application in the Jews' Deaf and Dumb School in Vienna, and at the new provincial institution at Wiener Neustadt. The exercises are carried out for half-an-hour daily; long sittings, especially at first, being followed by fatigue of the auditory

to teach by the ... But the teachers find
the time during ... ren appreciate what is sp...
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... ance of the Jews' school in Vie...
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... On the other hand, Bezold
... deaf mutes after a long course
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... But Bezold's test does not ...
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... the same operator always ...
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... an interesting ...
... the application ...

Assuming that 25 per cent of the inmates of Deaf an Institutions may and should be educated by the oro-acousti what must be done with the rest ? As few signs as possib finger spelling at all, should be used in the education of the The small class of cases of acquired deafness which ha so late in life (say 7 to 12 years) that good speech exist complete deafness has resulted, must be made to pr speech by the use of the oral method, and must be taught If possible, signs and finger spelling should not be u education. Unfortunately, some of these children m readers; the lack of development on which deafness de disease which has caused the deafness, being as intellectual damage or deficiency. Aphasics who h weak-minded children who hear, but cannot speak of Hörstummheit, or congenital lack of comprehens should not be trained in the institutions for the dea all. Special schools or classes should be arranged fo should be trained in the institutions for weak-mind children.

There remains, however, the subject of how rest of the deaf and dumb, say about 70 per ce This subject is undoubtedly one for the educati the practitioner, but there are two consider questions, the consideration of which will right understanding of this subject: (1) W articulation and of lip-reading is to be set intelligence of the child develop as far and pure oral method, as on the finger method method.

With regard to the first question, one must c between the position of the deaf child when teachers and relations on the one hand, and w on the other. Teachers and relations get ac liar speech of the orally-trained deaf mute. he says; they also speak with special dis

emphasized lip-movements, and the deaf mute reads their lips well. With the outside world it is quite different. The average deaf mute neither distinguishes what the average citizen says, nor does the average citizen make out what the average deaf mute says. So that after he leaves school, the average deaf mute falls back on some form of sign-language as the means of communicating with the outside world.

The second question, as to the effect on the mental development of the child, of the oral as against the finger method, is one about which teachers of the deaf cannot agree. The advocates of the oral method state that under the pure oral system, intelligence develops further and more rapidly than under the finger system, whilst the advocates of the finger system maintain that the opposite is the case.

Assuming that mental development and the power to use language develop equally under the two systems, the orally-taught deaf mute leaves school in a better position to communicate with the hearing world, than does the finger-taught deaf mute. But he will, except in the case of the semi-deaf, in most cases fall back on the use of signs and writing to aid his speech, when communicating with his hearing fellows throughout his after life. In his intercourse with other deaf mutes he will also use signs very largely. At church and at public meetings the speaker will largely use signs in addressing him, and except that the signs used are less conventional, and therefore more expressive, he will be much more like the finger-speaking deaf than is usually supposed. The writer, who has seen deaf-mute teaching carried on in Frankfort, Munich, Vienna, Dresden, Berlin, and Hamburg, and who has conversed with many teachers in these cities, has also seen the religious services of the adult deaf in Germany, and has talked with the adult deaf there. Whilst inclined to teach by the oral system wherever this can be carried out, he is quite sure that in later life pure oralism is the exception, and that most deaf mutes to a great extent use signs and writing to aid them in communicating with each other and with their hearing fellows.

8. ℞.—Acid. Carbol. Liq. - - ♏xx
Vaselini - - - ℥j

To relieve the itching due to eczema of the external auditory canal. To be introduced on a well-protected cotton-tipped probe, and spread over the walls of the canal.

9. ℞.—Sodii Bicarb. - - - gr. x
Glycerini - - - ʒj
Aquæ - - - ℥j

For softening hard ceruminous collections. Introduce a few drops morning and night into the ear, after warming the solution. Remove by syringe after two days.

10. ℞.—Ol. Carbol.

Introduce into the ear for the expulsion of insects.

11. ℞.—Spt. Vin. Rect.

To be used, after careful cleansing of the middle ear, for the control of exuberant granulations.

12. ℞.—Acid. Borac. - - - gr. x
Spt. Vin. Rect. - - ℥j

To be used as above indicated.

13. ℞.—Resorcin - - - gr. xx
Spt. Vin. Rect. - - ℥j

To be used as above indicated.

14. ℞.—Zinci Sulph. - - - gr. iij
Aquæ - - - ℥j

To be used, after warming, for the stimulation of the granulations, in a slowly healing tympanic cavity in which no cario-necrotic patches are discoverable.

15. ℞.—Liq. Hydrogen. Perox. - 5–10 vols.

To be used as an ear-bath, over a period of 5 minutes before syringing, for the purpose of loosening tough masses of discharge. The meatus must be filled with the solution, which should be warmed.

16. ℞.—Argenti Nitratis - - gr. v
Aquæ - - - - ʒij

A few drops to be instilled into the ear, for a period of 5 minutes before syringing, in obstinate cases of discharge where the perforation is large. The silver should be removed by means of *plain* warm water. The treatment should not be repeated oftener than once a week.

17. ℞.—Cocainæ Hydrochlor. - - gr. xx
Aquæ - - - - ad ʒij

To be used for 10 minutes as an ear-bath before any operation within the tympanic cavity—a perforation in the tympanic membrane already existing.

18. ℞.—Menthol
Acid. Carbol.
Cocainæ Hydrochlor. āā gr. xv

To be painted over the tympanic membrane, or introduced through a perforation into the tympanic cavity two minutes before an operation on the middle ear.

The solutions used as instillations and ear baths should, with the exception of the spirituous solutions, be used warm. The warming may be effected either by standing the bottle containing the solution in a bowl of hot water, or by pouring the solution into the ear from a spoon which has just been removed from hot water. The patient should lie on his side with the affected ear upwards.

19. ℞.—Acid. Carbol. - - ʒj
Aluminis - - ʒj
Glycerini - - ℥j
Aquæ - - ad ℥vj

Gargle for use in inflamed conditions of the throat when ear complications are feared, or have become established. To be used with an equal quantity of warm water.

20. ℞.—Sodii Bicarb. - - ℥j
Sodii Biborat. - - ℥j
Sacch. Alb. - - ad ℥iv

For the removal of crusts and other collections of mucus from the nose. A teaspoonful to a teacupful of warm water to be used as a nasal douche.

21. Insufflations.

After the middle ear has been cleansed, if the discharge be slight, powder may be blown in. The best are Boracic Acid; equal parts of Iodoform and Boracic Acid; Aristol; Iodol. All such powders must be removed by the syringe at each dressing, and the ear carefully dried before fresh powder is introduced. Iodoform often, and Boracic Acid sometimes, excites eczema.

22. Lotions. For use with the Aural Syringe.

The best of these are warm solutions of Carbolic Acid 1–60, of Boracic Acid (saturated solution), or of Bichloride of Mercury 1–3000. If the discharge be tough and flaky, it is well to use an ear bath of Hydrogen Peroxide first. (See Formula 15.)

23. A normal, or rather a *physiological* saline solution is made by dissolving Chloride of Sodium in boiled water in the strength of ·75 %. It is used when the operator's object is to remove discharge from the middle ear, which has been already made as aseptic as possible, and when it is desirable to avoid injury to grafts.

Injections by the Eustachian Tube.

24. ℞.—Sodii Bicarb. - - gr. x
Aquæ - - ad ℥j

25. ℞.—Vaselini Liq. steril.

26. ℞.—Pilocarp. Hydrochlor. - gr. viij
Aquæ - - ad ℥j

27. ℞.—Potass. Iodidi - - gr. viij
Aquæ - ad ℥j

Five to 10 drops of any of these solutions [illegible] be introduced, after warming, by the Eustachian catheter.

28. For the relief of tinnitus (in a[illegible]tion to the internal treatment by the Bromides, Hydrobromic Acid, etc.), [illegible]ounter-irritants may be applied to the mastoid process.

29. Caustics may be applied to the middle ear.

In addition to Nitrate of Silver already referred to (Formula 16) as an ear-bath, the best of these are Chromic Acid and Trichlor-acetic Acid, which may be applied through a vulcanite speculum on the end of a firmly-made cotton tip, and the effects of which can be immediately stopped by a current of warm water.

INDEX.

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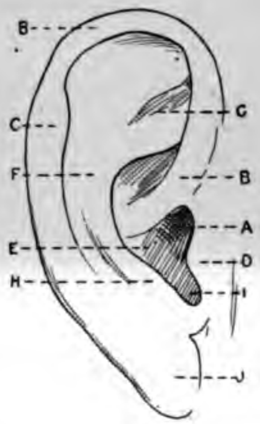
STEREOGRAMS

I—III.

STEREOGRAM I.—DISSECTION TO SHOW THE WHOLE ORGAN OF HEARING.

The squamous portion and the upper part of the petrous have be removed by a saw-cut passing from above and behind the external e obliquely forwards and inwards. The anterior walls of the external audit meatus, tympanic cavity, and Eustachian tube have also been remov (*Hunterian specimen*).

A. Mastoid antrum.
B. Part of tympanic attic.
C. Vestibule with bristle in it.
D. Eighth nerve in internal auditory meatus.
E. Cochlea.
F. Carotid canal with bristle tied in it.
G. Eustachian tube with bristle tied in it.
H. Tympanic ring.
K. External auditory meatus.
N. Auditory ossicles.

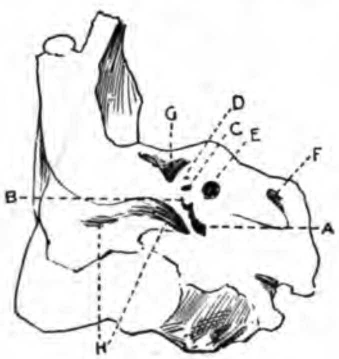


STEREOGRAM II.—THE AURICLE OF THE RIGHT SIDE.

The stereogram shows the convolutions of the cartilaginous plates forming t auricle.

(A) External auditory meatus: above it (B) the helix with Darwin's tubercle (C) well-marked: in front of and slightly overlapping the external auditory meatus lies (D) the tragus. The deep concavity (E) at the bottom of which the meatus lies is called the concha, and this is bounded above and posteriorly by (F) the antihelix. The antihelix divides at its upper extremity into two ridges which enclose (G) the scaphoid fossa, while its lower extremity terminates in a prominence (H) the antitragus. The notch (I) between tragus and antitragus is called the incisura intertragica. The lowest part (J) of the auricle, in which the helix loses itself, is called the lobule and is devoid of cartilage.

STEREOGRAM III.—VERTICAL SECTION OF THE EAR FROM BEHIND (ANTERIOR HALF).



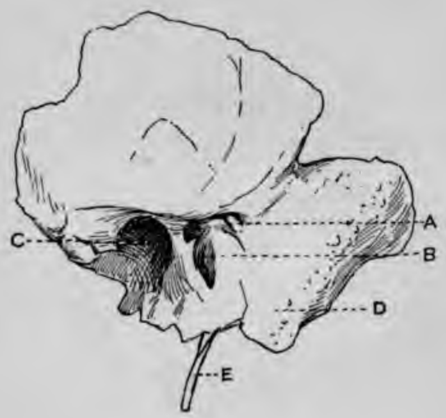
The left temporal bone and external ear of an adult divided in a pla passing through the external auditory meatus, rather behind its centre, and n quite transverse to the head, the inner end being a little further forward than t outer. (*Hunterian specimen*).

A. Tympanum, with oblique position of membrana tympani we shown.
B. Stapes in position, with its foot-plate filling the fenestra ovalis.
C. Aqueductus Fallopii.
D. Horizontal semicircular canal in section.
E. Vestibule.
F. Internal meatus.
G. Antrum mastoidei.
H. Hollows in external meatus in which foreign bodies often lodge.

NOTE.—The "isthmus" or narrow part of the canal is well seen in thi specimen.

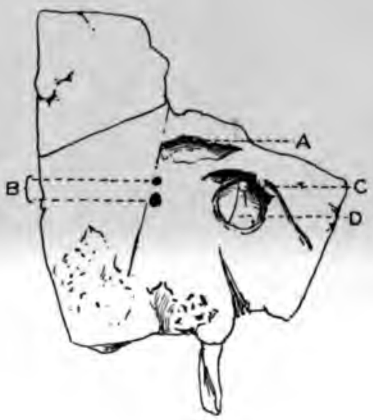
STEREOGRAMS

IV—VI.



STEREOGRAM IV.—LEFT TEMPORAL BONE (*To show Henle's spi*

A. Henle's spine with fossa behind it.
B. External meatus.
C. Glenoid fossa.
D. Mastoid process.
E. Styloid process.

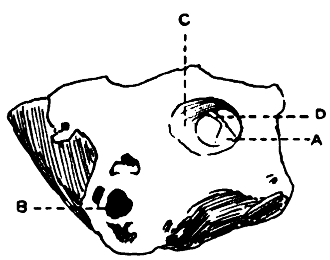


STEREOGRAM V.—VERTICAL SECTION OF RIGHT TEMPORAL BONE.

Made in a plane parallel to and three-quarters of an inch in fro the upper border of the petrous portion. A wedge-shaped portion has been removed from the cut surface, to show the mastoid antrum.

A. Mastoid antrum with the aditus in its fore part.
B. Mastoid cells.
C. Short process of malleus.
D. "Cone of light."

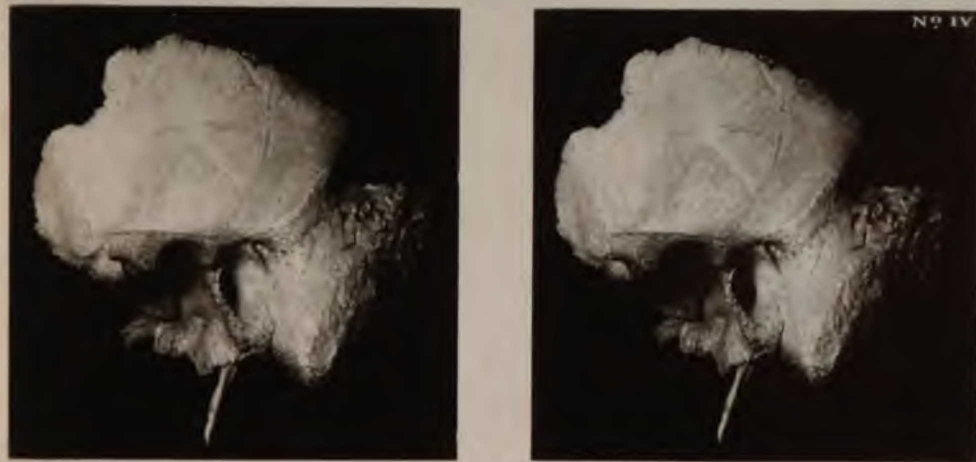
STEREOGRAM VI.—VERTICAL SECTION OF RIGHT TEMPORAL BONE IN A YOUNG SUBJECT.



The specimen shows the membrana tympani concave on the **outside,** handle of malleus and cone of light. **The mastoid is small but its cells** seen to be very large and of the pneumatic type.

A. Cone of light.
D. Handle of malleus.
B. Mastoid cells.
C. External meatus.

Nº IV



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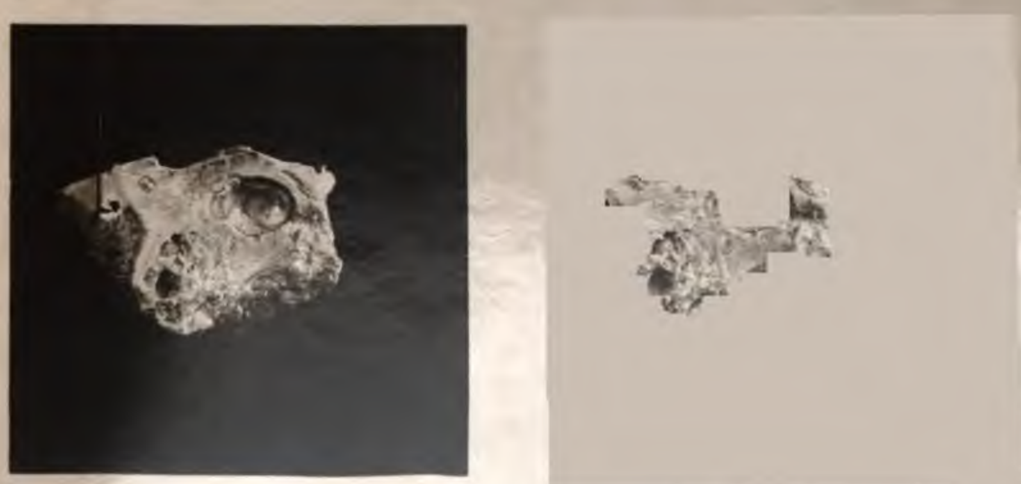


STEREOGRAMS

VII—IX.

STEREOGRAM VII.—DIPLOËTIC MASTOID PROCESS.

A saw-cut has been made to pass through the mastoid p of the right temporal bone, parallel with the side of the head. diploëtic cells are seen to form the bulk of the mastoid pı Hardly any of the cells are larger than a pea.

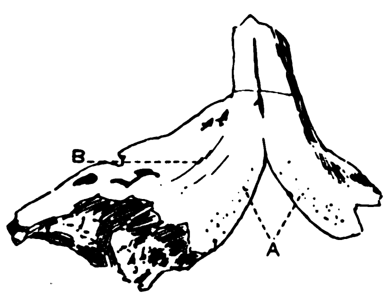
The specimen also shows well the linea temporalis (A) marks for the operator the floor of the middle fossa of the Between the linea temporalis and the mastoid cells, above and t the external auditory meatus, are seen Henle's spine (B) an supra-spinous fossa. The anterior wall of the external auditory n (C) (the tympanic plate formed from the tympanic ring) is well and its proximity to the articular surface for the lower jaw s be noted.

STEREOGRAM VIII.—PNEUMATIC MASTOID PROCESS.

Vertical section through a left temporal bone showing the m cells (P) to be of very large size. The saw-cut passes through the e auditory meatus close to the membrana tympani, which is seen natural position.

The conical appearance of the membrane is well shown with the (A) occupied by the lower extremity of the handle of the mallei umbo). At the upper extremity of the handle is a well marked p (B) the short process of the malleus. The bone has been broken som immediately above and in front of the membrane; and the letter (C) the entrance of the Eustachian tube into the tympanum.

STEREOGRAM IX.—EBURNATED MASTOID PROCESS.



The mastoid has been divided by a saw-cut through its axi passing obliquely from the tip upwards and backwards.

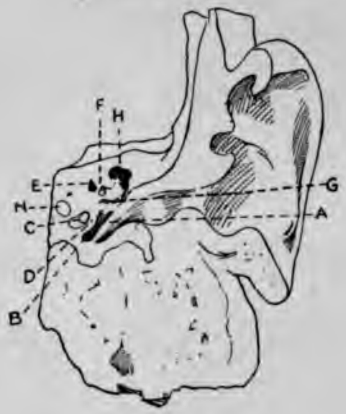
The cells (A) thus exposed are seen to be of very small size, case larger than a pin's head. The groove for the sigmoid sinus c seen (B) immediately internal to the line of section, which passes obl through it.

STEREOGRAM

STEREOGRAMS

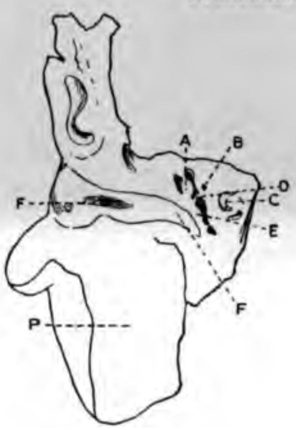
X—XII.

Stereogram X.—Vertical Transverse Section of the Ear from Before, Posterior Half of. Specimen III (*Hunterian.*)



A. Membrana tympani closing bottom of external meatus.
B. Tympanum.
C. Cochlea with bristle passing forwards and upwards to vestibule.
D. "Promontory" formed on inner wall of tympanum by first turn of cochlea.
E. Superior semicircular canal with bristle passing downwards into vestibule.
F. Facial nerve cut across as it lies in aqueductus Fallopii.
G. Foramen ovale.
H. Attic, with aditus ad antrum.
N. Auditory nerve in internal meatus.

Stereogram XI.—Vertical Transverse Section of the Ear from Behind.

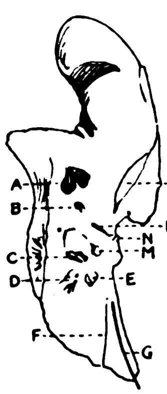


Anterior half of a left temporal bone and external ear divided in similarly to No. X, but three mm. further forward (*Hunterian specimen*)

A. Articular surface on head of malleus.
Superior ligament of malleus is also shown.
B. Aqueductus Fallopii.
C. Cochlea.
D. Tendon of tensor tympani passing across tympanum to malleus.
E. Handle of malleus.
F F. Hollows in external meatus in which foreign bodies often lodge.
P. Parotid gland.

The hairs in the outer end of the meatus are well seen in this speci

Stereogram XII.—Dissection (Second View) to show the Whole Organ of Hearing.



This is the same specimen as No. I, viewed from above (*Hunterian spe*

A. Mastoid antrum.
B. Part of tympanic attic.
C. Vestibule.
D. Part of eighth nerve in internal auditory meatus.
E. Cochlea.
F. Bristle in carotid canal.
G. Bristle in Eustachian tube.
K. External auditory meatus.
M. Tendon of tensor tympani muscle.
N. Head of malleus.
I. Incus (long process lying in aditus ad antrum).

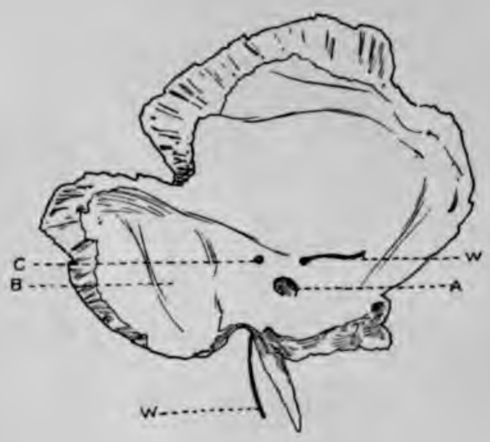
Note.—A bristle passes between malleus and incus.

STERE(AMS

XI)

STEREOGRAMS

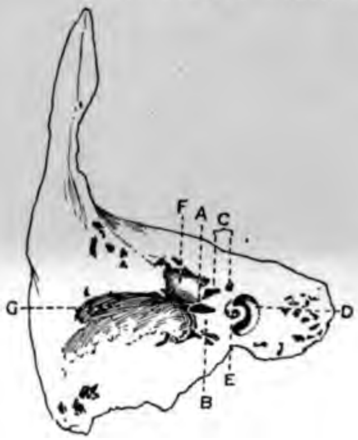
XIII—XV.



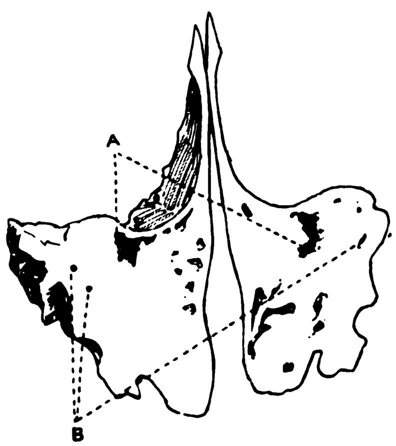
Stereogram XIII.—Internal Aspect of Left Tempo[
Bone.

A. Internal auditory meatus.
B. Sigmoid sinus.
C. Aqueductus vestibuli.
W. W. Wire following the course of the facial nerve, but emerging at the hiatus Fallopii.

Stereogram XIV.—Vertical Transverse Section through Temporal Bone, showing Cochlea.



A. Fenestra ovalis.
B. Promontory.
The fenestra rotunda is obscured by the promontory owi the position in which the photograph is taken.
C. Aqueductus Fallopii shown in two positions, owing to the sa having passed through the "knee."
D. First turn of cochlea.
E. Second turn of cochlea.
F. Tympanic attic.
G. External meatus.

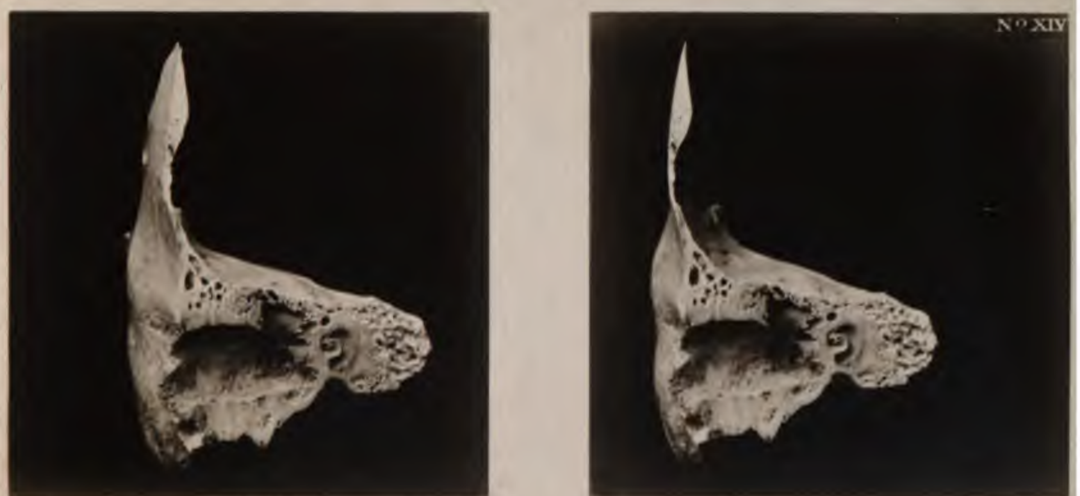


Stereogram XV.—Vertical Transverse Section through Ri Mastoid Process showing the Mastoid Antrum (A) and Mastoid Cells.

B. Posterior semicircular canal cut across.

Notice the thinness of the plate of bone separating the mastoid antrum from the middle fossa of the skull.


Nº XIII


Nº XIV


Nº XV

STEREOGRAMS

XVI—XVIII.

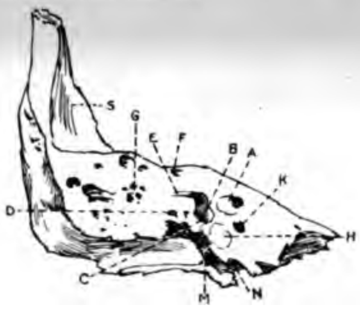
STEREOGRAM XVI.—HORIZONTAL SECTION OF TEMPORAL BONE (RIGHT S

Upper half of temporal bone, the lower half of which is shown in No. X

G. Glenoid fossa.
M. Attic of tympanum.
C. Canal for tensor tympani muscle.
K. Cochlea.
F F. Bristle in aqueductus Fallopii.
I. Outer part of internal meatus.
S. Bristle in superior semicircular canal.
P. Posterior semicircular canal.
Note that this unites with above, and that they continue as one canal between S and the vestibule V.
E. External (or horizontal) semicircular canal, the plane of which has been cut obliquely by the plane of section.
A. Antrum mastoidei separated from M by a bridge of bone forming the floor of the aditus.
H. External meatus.

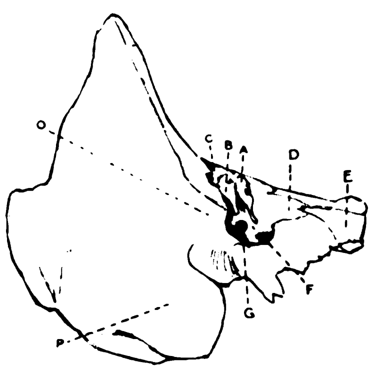
STEREOGRAM XVII.—LOWER HALF OF TEMPORAL BONE (RIGHT SIDE.)

Divided by a saw cut passing almost horizontally through it about the junction of upper and middle third the external meatus.



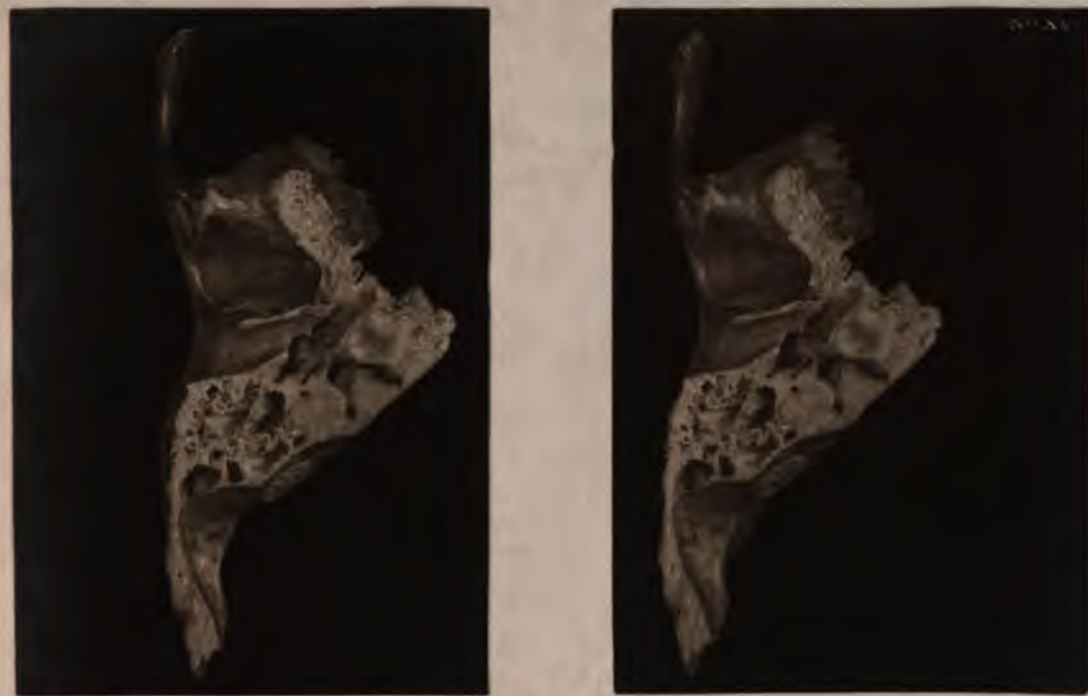
A. Internal meatus.
B. Vestibule.
C. Edge of oval window lying above promontory.
D. Aqueductus Fallopii.
E. Part of horizontal semicircular canal.
F. Part of posterior semicircular canal.
G. Floor of mastoid antrum.
H. Cochlea.
K. First turn of cochlea, cut across.
M. "Cellar" of tympanum or "hypotympanic recess."
N. Eustachian tube.
S. Sigmoid sinus.

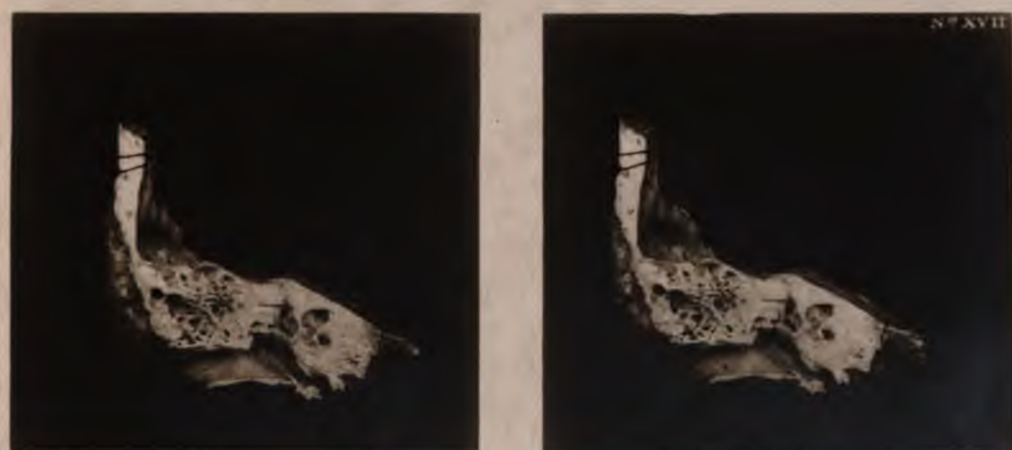
STEREOGRAM XVIII.—DRY SPECIMEN WITH THE AUDITORY OSSICLES REPLACED IN POSITION.



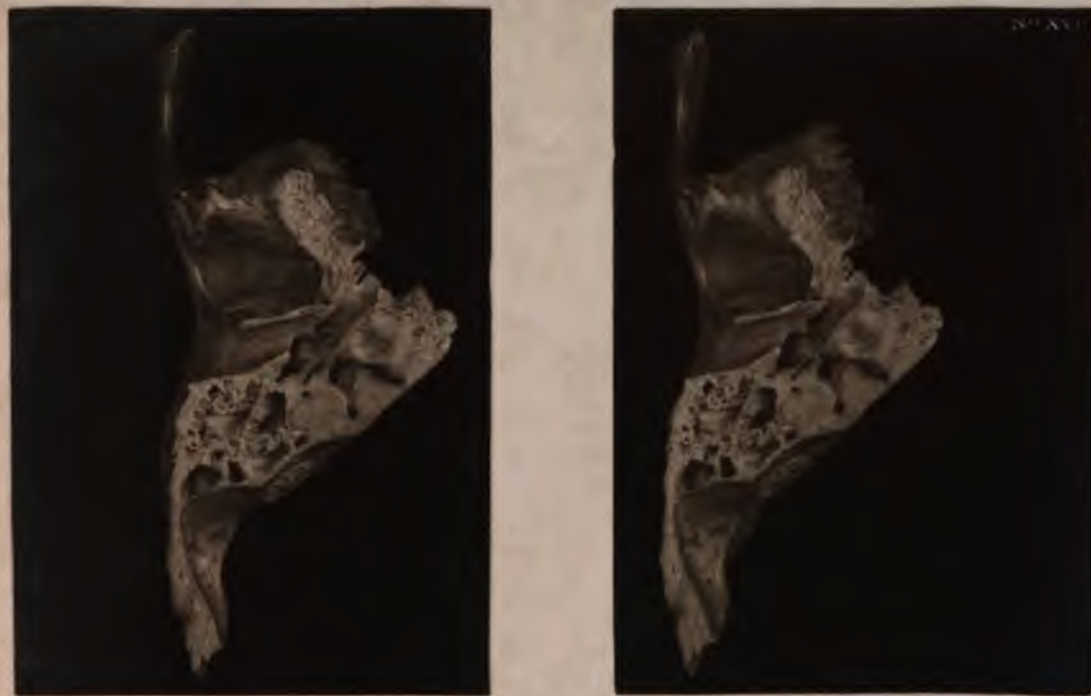
A. Malleus.
B. Incus receding from tip of long process of which can be seen the stapes with its foot plate in the fenestra ovalis.
C. Antrum mastoidei.
D. Eustachian tube.
E. Carotid canal.
F. Promontory.
G Fenestra rotunda.
O. External meatus.
P. Mastoid process.

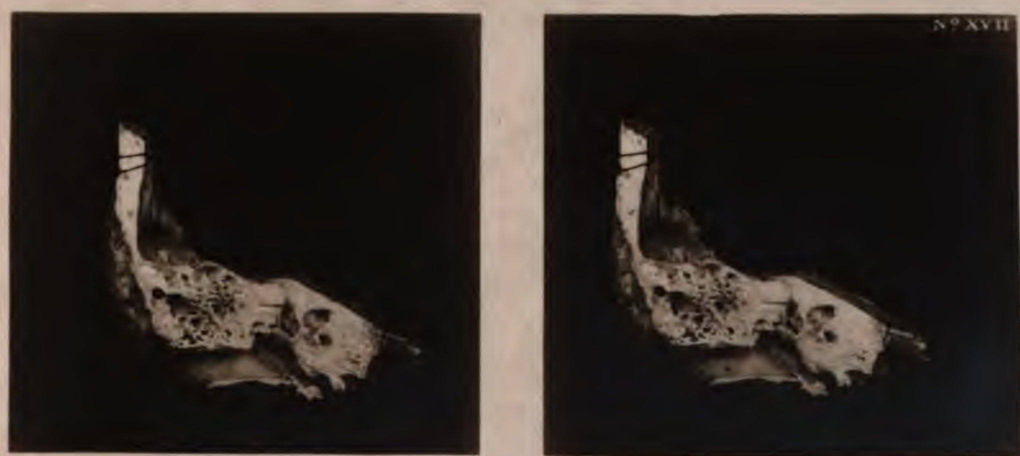
STEREOGRAM.





STEREOGRAM.





STEREOGRAMS

XIX—XXI.

Stereogram XIX.—Internal Tympanic Wall Exposed

Vertical section of right temporal bone. The saw-cut has been m[illegible] right angles to the side of the head removing the anterior wall [illegible] external meatus and opening the cochlea, but passing entirely in front [illegible] internal meatus.

A. Fenestra ovalis.
B. Facial canal opened at the extreme anterior part of the "knee."
C. Upper end of the canal for tensor tympani muscle.
D. Fenestra rotunda.
E. Promontory.
G. "Attic" of tympanum.
F. Cochlea.
H. Henle's spine with supra-spinous fossa behind it.

Note.—The perforations for blood-vessels in and around the fossa are well marked.

Stereogram XX.—Internal Tympanic Wall Exposed.

Section to show the internal tympanic wall. A vertical trans[illegible] saw-cut has been made down to the tympanum, and the halves have been separated by lateral movement of the saw.

A. Fenestra ovalis.
B. Fenestra rotunda.
C. Facial canal.
D. Carotid canal.
E. Promontory.
F. Bony wall of external meatus.
G. Upper part of canal for tensor tympani muscle.

Stereogram XXI.—Same as above, with Stapes fixed in the Oval Window.

In these two specimens the saw-cut has been made a little further back than in the preceding one (No. XIX) and the aditus is thus seen behind the fenestra ovalis leading up to the antrum mastoidei.



STEREOGRAMS

XXII—XXIV.

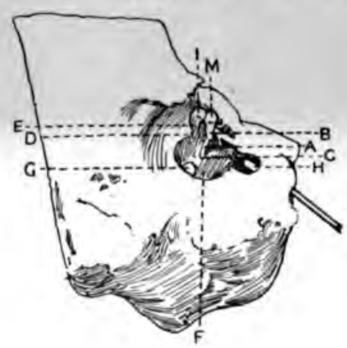
Stereogram XXII.—Exposure of Tympanum (Membrane removed).

External aspect of a right temporal bone, with the soft parts and membrana tympani removed. The middle ear and its structures can be seen through the external auditory meatus in their natural positions.

(A) Handle of malleus with (B) short process and (C) umbo. Behind, and slightly more deeply situated, lies (D) the long process of the incus. Arching backward from the tip of this process, a fold of mucous membrane can be seen which covers the tendon of the stapedius muscle as it passes forward to the neck of the stapes. The posterior edge of the notch of Rivini is well marked, and from it can be seen, arching forward to the short process of the malleus, a ridge (E) which is the fold of membrana tympani representing the border of Shrapnell's membrane, and containing the posterior part of the chorda tympani nerve, which leaves it at about the middle to pass forward between the incus and malleus. On the middle of the internal tympanic wall can be seen (F) the promontory: behind this is the foramen rotundum (G); while in the dark recess (H) lies the Eustachian tube; within its upper angle the prominence caused by the canal for the tensor tympani muscle can be seen.

Stereogram XXIII.—Right Temporal Bone.

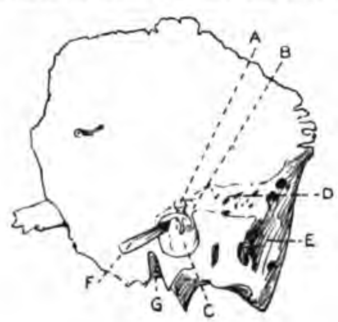
The upper and anterior parts of the tympanic ring have been removed, and a probe has been placed in the Eustachian tube. The position of the ossicles is well shown, lying, as they do, with the greater part of them in the attic of the tympanum and above the level of the upper wall of the external meatus.



A. Handle of malleus.
B. Short process.
C. Umbo.
D. Long process of incus receding from the tip of which are the crura of the stapes, the view of posterior crus being covered by the tendon of the stapedius muscle, which is well seen as it passes back to the apex of the pyramid.
E. Chorda tympani nerve.
F. Promontory.
G. Foramen rotundum.
H. Eustachian tube with probe in it.
I. Head of incus articulating with head of malleus (M).

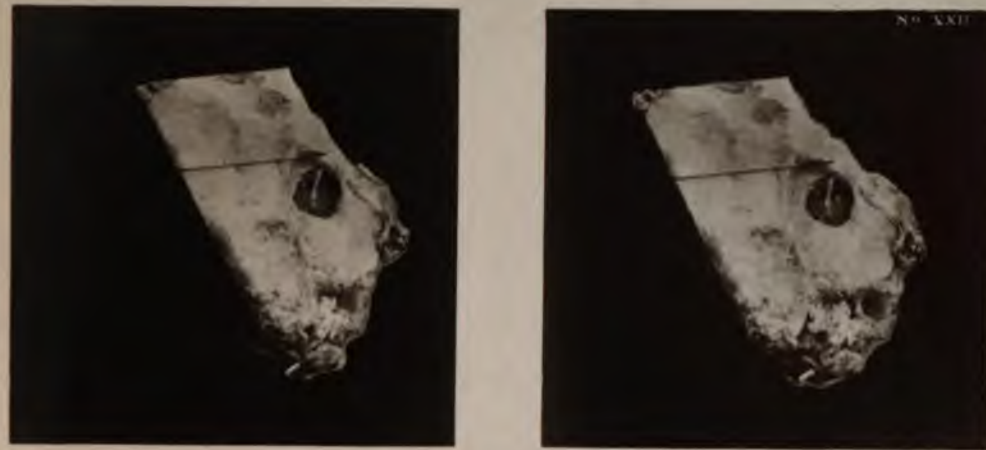
Stereogram XXIV.—Tympanic Membrane and Ossicles from the Inside.

Vertical section through length of petrous and mastoid portions of temporal bone. The section follows a sinuous course in order to show the various structures.



A. Malleus with its handle attached to the tympanic membrane (C), which is viewed from the inside.
B. Incus with its short process lying in the aditus ad antrum.
D. Antrum opened.
E. Mastoid and mastoid cells.
F. Tensor tympani muscle lying above the Eustachian tube, and with its tendon passing forward to base of handle of malleus.
G. Part of carotid canal.

STEREOGRAM.



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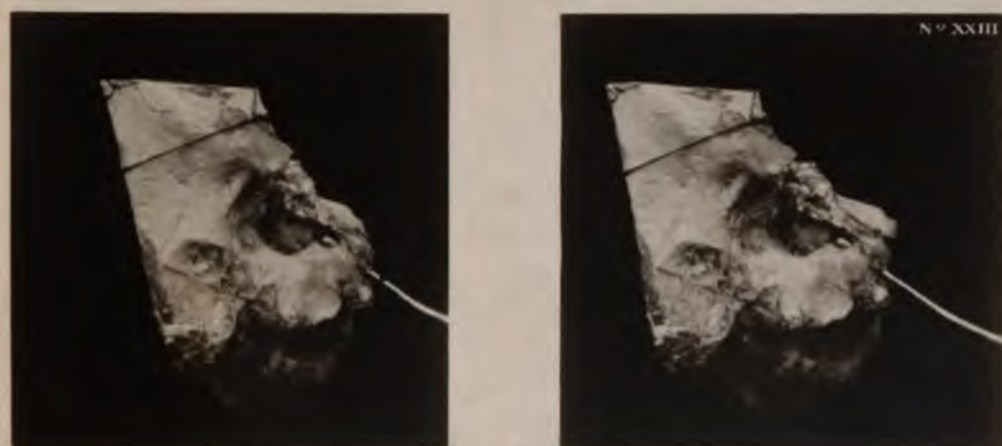


N° XXIII

N° XXIV

STEREOGRAMS

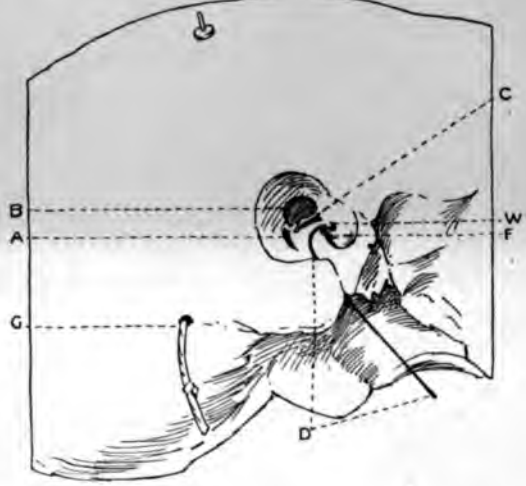
XXV—XXVII.

STEREOGRAM XXV.—TO SHOW THE "COMPLETE MASTOID OPERATION."

The mastoid antrum was first opened and then the "bridge" of bone forming the outer wall of the aditus was removed. The mastoid cells were then ablated backwards and downwards towards the periphery of the mastoid.

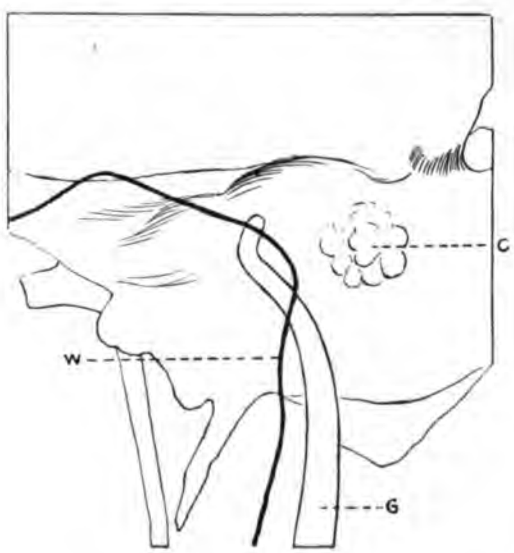
A. The facial ridge is well shown, the dense bone forming it contrasting well with the looser texture of the mastoid in its neighbourhood. The wedge-like shape of the cavity formed (the thick end of the wedge being at the antrum) is also well illustrated.

B. The circular opening in the bone behind the mastoid indicates the situation for trephining in cases of cerebellar abscess.



STEREOGRAM XXVI.—EXPOSURE OF THE FACIAL AND SEMICIRCULAR CANALS.

All three semicircular canals have been laid open; the posterior (A) and superior (B) are easily recognised from their positions, the external (C) lies obliquely between the two. The facial nerve (D) represented by a bristle, is seen at first within the middle ear, but afterwards passing backwards and downwards within the opened Fallopian canal towards the stylo-mastoid foramen. Within the middle ear a small ring of the bony canal has been left, and below the opened part of the canal is seen the oval window (W). The canal for the tensor tympani muscle (F) is seen passing downwards towards the Eustachian tube. The mastoid emissary vein is represented by a piece of knotted string (G) which projects from the foramen about three-quarters of an inch behind the tip of the mastoid process.

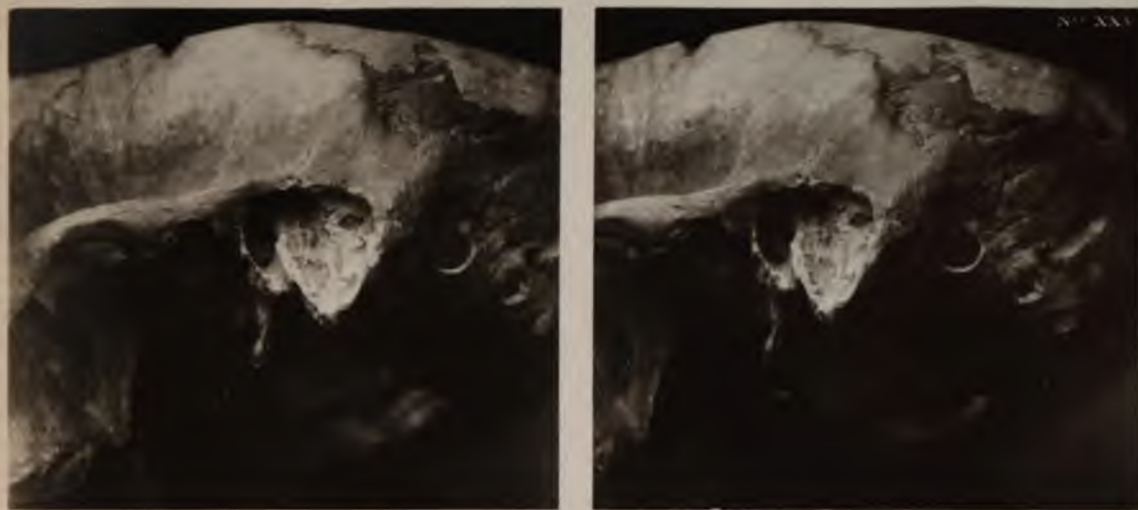


STEREOGRAM XXVII.—X-RAY STEREOGRAM OF THE TEMPORAL BONE.

A wire (W) has been passed along the Fallopian canal from the stylo-mastoid foramen, and brought out at the hiatus Fallopii. A Stacke's guide (G) modified so that the beak of it is turned in a horizontal plane (*i.e.*, one parallel to that of the handle) through a small angle (say 20°—30°), is placed in position in the aditus.

The picture shows the beak of the guide protecting the nerve.

The general structure of the temporal bone is well shown, *e.g.*, mastoid cells at C. Notice that no part of the temporal bone is free from cells except the squamous portion.


N° XXV


N° XXVII

STEREOGRAMS

XXVIII—XXXI.

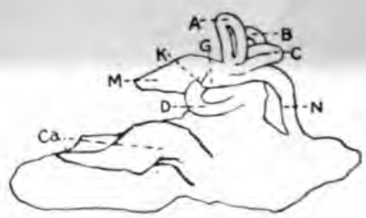
Stereogram XXVIII.—Metal Corrosion Cast of Labyrinth, from Behind and a little Below.

M. Internal meatus.
A. Vestibular branch of auditory nerve.
S. Superior, (P.) posterior, and (E.) external (or horizontal) semicircular canals.
N. Descending part of facial nerve.
J. Jacobson's nerve situated between carotid and jugular.
C. Lowest turn of the cochlea.

Stereogram XXIX.—Metal Corrosion Cast of the Labyrinth, from the Inner side.

M. Internal meatus.
A. Vestibular branch of the auditory nerve.
S. Superior, (P.) posterior, and (E.) external semicircular canals.
N. Descending part of the facial nerve.
K. Knee of facial, from which is given off the great superficial petrosal branch of the Vidian nerve.
J. Jacobson's nerve.
Ca. Carotid canal.
C. Lowest turn of cochlea.

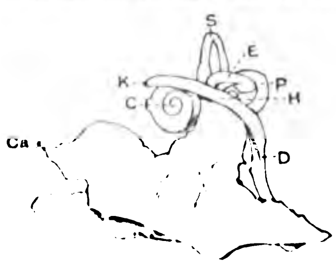
Stereogram XXX.—Wax Corrosion Preparation of the Left Temporal Bone, viewed from Above and in Front.



A. Superior, (B.) posterior, and (C.) external (or horizontal) semicircular canals.
N. Facial nerve (the letter points to the nerve at its descending part).
G. Knee of facial nerve with ganglionic enlargement.
K. Point of origin of Vidian nerve (great superficial petrosal branch).
M. Internal meatus.
D. Cochlea (the letter points to the first turn).
Ca. Carotid artery (the letter points to the bend of the artery).

Stereogram XXXI.—Wax Corrosion Preparation of the Left Temporal Bone.

Viewed from the front and outer side, showing the facial nerve in its whole course from the "knee" to the stylo-mastoid foramen, and its relation to the cochlea and semicircular canals.



K. Knee of facial from which the Vidian nerve comes off (great superficial petrosal branch).
H. Horizontal portion and (D) descending or vertical portion of facial nerve. The bend between (H) and (D) is the part situated at the junction of the floor and inner wall of the aditus, and so is liable to injury in removing the "bridge" in the radical operation.
C. Cochlea.
S. Superior, (P.) posterior, and (E.) external (or horizontal) semicircular canals.
Ca. Carotid artery.

STEREOGRAM

STEREOGRAMS

XXXII—XXXV.

Fig. A

Fig B.

STEREOGRAM XXXII.—THE LEFT TEMPORAL BONE OF A CHILD AT B
MACERATED AND SEPARATED INTO SQUAMOUS AND PETRO-MAS
PORTIONS.

(*Hunterian specimen*).

Fig. **A.** SQUAMOUS PORTION (S) with tympanic ring (R) attached.
point of union is marked by a bristle (B) in the notch of Riv

Fig. **B.** PETRO-MASTOID PORTION.

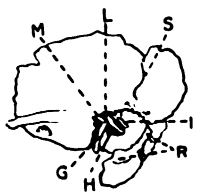
P. Promontory.
E. Eustachian tube.
O. Fenestra ovalis. Immediately above and behind this is (F) the facial ridge.
A. Aditus ad antrum. The outer wall has been removed.
N. Antrum mastoidei already well developed, although the re the mastoid is practically non-existent.
R. Fenestra rotunda, almost hidden by promontory.

STEREOGRAM XXXIII.—THE LEFT TEMPORAL BONE OF A CHILD AT BIRTH MACERATED.

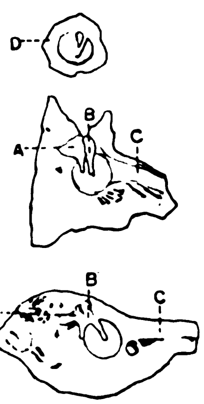
(*Hunterian specimen.*)

P. Promontory.
E. Eustachian tube.
F. Lower opening of aqueductus Fallopii. A bristle placed in this canal to show course of facial nerve is seen emerging from the opening.
S. Squamo-mastoid suture still patent.
R. Tympanic ring. Note that this ring is not complete at its upper part. This persists as the notch of Rivini. The "mastoid process" is still undeveloped.

STEREOGRAM XXXIV.—DISSECTION OF THE LEFT TEMPORAL BONE OF A FŒTUS TO SHOW THE STRUCTURES MIDDLE EAR. (*Hunterian specimen.*)



M. **Head of malleus.**
H. **Handle of malleus.**
L. **External ligament of malleus.**
G. **Processus gracilis, enclosed in the anterior ligament of malleus. This process o malleus afterwards becomes enclosed in the Glaserian fissure, and is almost al broken in the attempt to remove the malleus.**
S. **Squamo-mastoid suture still patent.**
I. **Incus. The chorda tympani nerve passing between this and the malleus can difficulty be seen in the stereogram.**
R. **Tympanic ring in process of formation. Note the complete absence of a ma process.**



STEREOGRAM XXXV.—THREE DRIED SPECIMENS SHOWING MEMBRANA TYMPANI OSSICLES (MALLEUS AND INCUS) FROM INSIDE. (*Hunterian*).

A. Incus.
B. Malleus.
C. Eustachian tube (outer wall).
D. Tympanic ring.

STEREOGRAM.

STEREOGRAMS

XXXVI—XXXVIII.

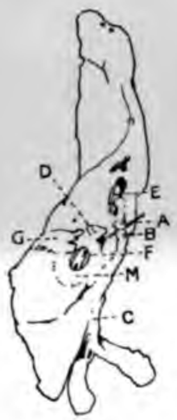
XVI.—The Organ of Hearing of a Fœtus. (*Hunterian specimen*).

P. Pinna.

E. External meatus.

M. Membrana tympani with conical appearance just as in adult, but without the handle of malleus shining through.

Note that the membrane is continuous in its upper and posterior part with the meatal wall, and does not show the usual angle found here in the adult.



TEREOG ... Middle and Internal Ear.

art ... uditory nerve injected. (*Hunterian specimen*).

...d of malleus with a black bristle ...ow the articulation.

...cus. (A bristle can be seen behind ...e stapedius muscle).

E. Aditus leading up to the antrum.

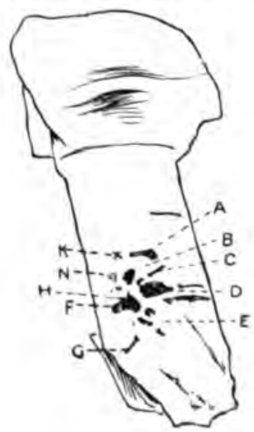
F. Cochlea.

G. Auditory and facial nerves together with injected artery accompanying them.

M. Capsule of labyrinth composed of dense bone.

C. Eustachian tube.

Stereogram XXXVIII.—Dissection of the Middle and Internal Ear (Left Side) Viewed from Above. (*Hunterian.*)



A. Incus, articulated with

B. Malleus.

Emerging between the incus and malleus, and obscuring the long process of the malleus, is a bristle (C) against which the chorda tympani nerve is well seen.

D. Middle ear or tympanum.

E. Cochlea well shown with, at its base, the branch of the auditory nerve entering it.

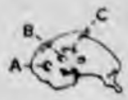
G. Bristle lying on floor of internal meatus, which has been unroofed and shows the auditory nerve dividing into two main branches, the cochlear and the vestibular, which latter is seen again dividing into two before it enters the vestibule (F).

H. Stapes with its foot-plate in fenestra ovalis, the upper wall of which has been removed. Between this and (K), which is placed in the mastoid antrum, is seen a bristle (N) inserted into the vertical part of the Fallopian canal, the horizontal part of which has been removed. Immediately to the outer side of this lies the floor of the aditus ad antrum, while between it and the foot-plate of the stapes is situated the "pyramid" from the apex of which emerges the stapedius.

STEREOGRAMS

XXXIX—XLII.

STEREOGRAM XXXIX.—BONY COCHLEA OPENED TO SHOW SPIRAL LAMINA.



A. Beginning of first turn with hook-shaped end of spiral lamina. The lamina at this part is very broad and almost touches the outer wall of the canal. By comparing the next two turns (B and C), which are smaller than (A), with (A), it will be seen that the breadth of the spiral lamina decreases as it ascends in greater proportion than does the sectional area of the canal. This results in the gradual increase of the distance separating the outer edge of the spiral lamina from the outer wall of the bony canal, until at the helicotrema [situated in turn (C) but not shown in stereogram] it becomes a maximum. Cf. *Plate II*, Schema of Cochlea.

STEREOGRAM XL.—WAX CORROSION PREPARATION OF INTERNAL EAR.

A. Superior semicircular canal.
B. Posterior semicircular canal.
C. External (or horizontal) semicircular canal.
D. Cochlea.
F. Fenestra ovalis leading to vestibule.
M. Internal meatus.

The horizontal part of the facial canal passes between (F) and the external semicircular canal (C), but it has been removed in the present specimen.

STEREOGRAM XLI.—DISSECTION OF BONY LABYRINTH (LEFT SIDE) VIEWED FROM INNER SIDE.

A. Superior semicircular canal opened.
D. Point where posterior semicircular canal unites with former. Part of this canal can be seen in the stereogram through the arch of (A).
B. External (or horizontal) semicircular canal.
C. Cochlea, opened. The columella and spiral lamina are well shown.
E. Vestibule, unopened.

STEREOGRAM XLII.—THE AUDITORY OSSICLES.

A. Malleus
B. Incus
C. Stapes.
D. Malleus with processus gracilis from [illegible] [illegible].
E. Ossicles articulated

STEREOGRAM.

STEREOGRAMS

XLIII—XLV.

STEREOGRAM XLIII.—FRESH SPECIMEN WITH TEGMEN TYMPANI AND TEGMEN ANTRI REMOVED.

A. Incus with its short process directed along the aditus ad antrum.

B. Head of malleus articulating with head of incus.

C. Os orbiculare and head of stapes.

D. "Eminentia arcuata," the prominence caused by the superior semicircular canal.

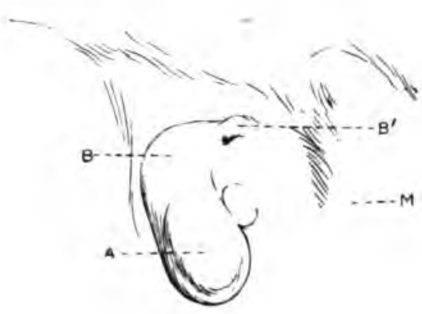
E. Antrum mastoidei.

F. Mastoid and mastoid cells.

STEREOGRAM XLIV.—EPITHELIOMA OF AURICLE.

The small growth is seen in the scaphoid fossa.

STEREOGRAM XLV.—MALFORMATION OF THE LEFT AURICLE.



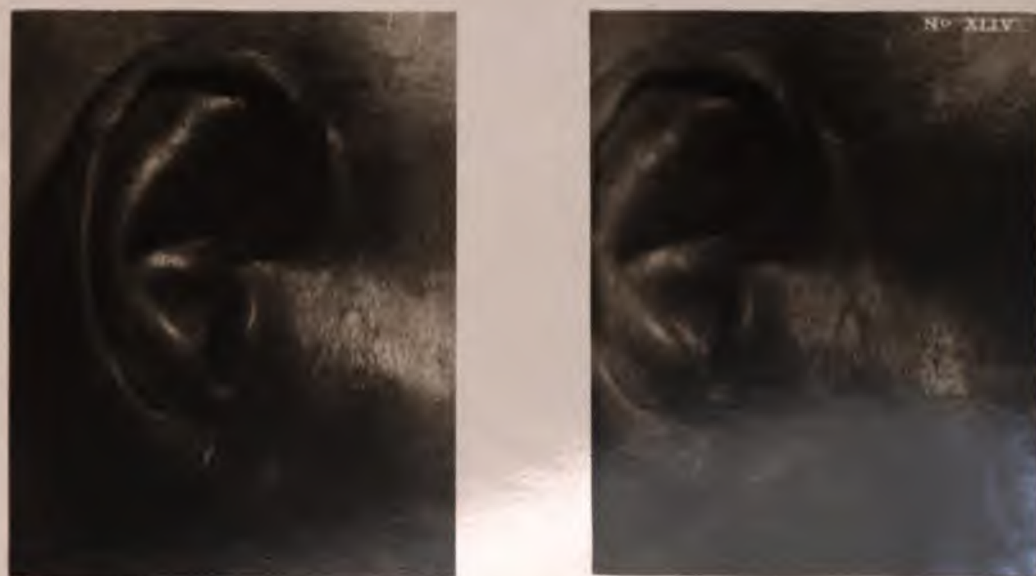
A. Lobule well-formed but rolled forward on itself and apparently covering the meatus.

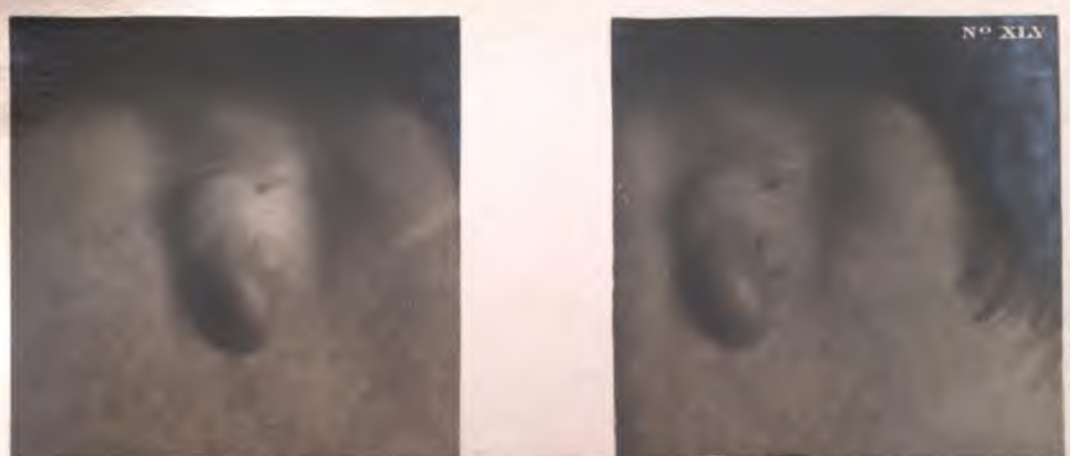
B, B'. Two nodules of cartilage which alone remain of the six described by His as taking part in the formation of the pinna. (B) is probably the nodule arising from Meckel's cartilage, which ought to have formed the tragus, but has instead become attached to the last-formed of all the parts, viz., the lobule, which arises from the second (or Hyoidean) arch.

M. Is situated on the mastoid process which seems to be quite normal.

The right pinna was quite normal.

STEREOGRAM





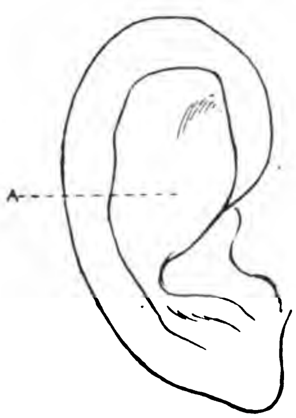
STEREOGRAMS

XLVI—XLVIII.

Stereogram XLVI.—Facies of Post-nasal Adenoids.

Stereogram XLVII.—Frost-bite of Pinna.

The greater part of the helix has been destroyed, and scarring extends to the antihelix.

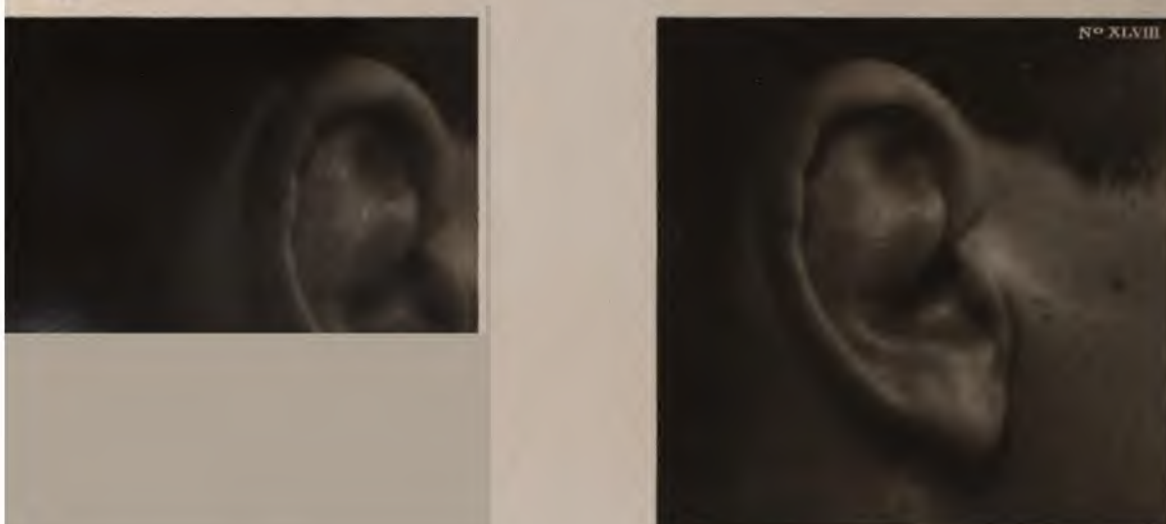


Stereogram XLVIII.—Traumatic Othæmatoma.

A. Blood tumour filling the lower part of the scaphoid fossa, and overhanging the concha.

This picture should be compared with Stereogram II.

STEREOGRAM



STEREOGRAMS

XLIX—LI.

Stereogram XLIX.—Shrivelled Ear.

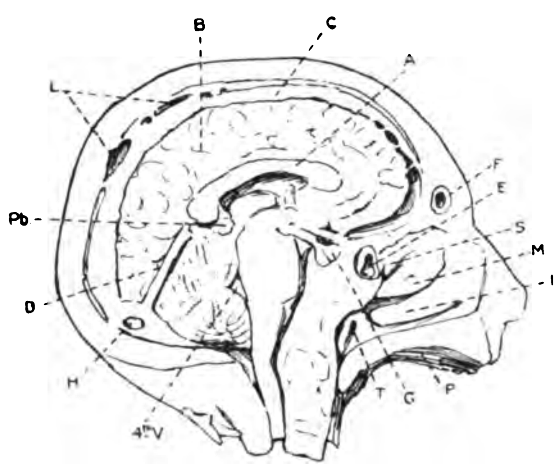
The result of an othæmatoma occurring in an insane woman. All the pinna, except the lobule, is involved

Stereogram L.—Shrivelled Ear.

Occurring in insane man. The scaphoid fossa and surrounding parts are the seat of the lesion.

Stereogram LI.—Median Longitudinal Section of Head.

From museum in anatomical department of Glasgow university. (*Photographed by permission of Dr. Cleland*).



A.	Corpus callosum with left lateral ventricle below it.
B.	Calloso-marginal fissure.
C.	Falx cerebri (only a rim left).
L.	Superior longitudinal sinus opened.
H.	Torcular Herophili.
D.	Tentorium cerebelli and straight sinus.
Pb.	Pituitary body.
4th V.	Fourth ventricle with pons and medulla in front of it.
G.	Pineal gland.
F.	Left frontal sinus with incomplete lamina dividing it from its fellow on the right.
E.	Sphenoidal sinus.
S.M.I.	Superior middle and inferior turbinated bodies over-hanging the corresponding meatuses.
T.	Lower extremity of Eustachian tube.
P.	Palate.

STEREOGRAM

STEREOGRAMS

LII—LIV.

STEREOGRAM LII.—NOSE AND ADJACENT PARTS FROM STEREOGRAM LI.

(*For description see Stereogram LIII.*)

S … NOSE TO SHOW EUSTACHIAN CATHETER IN POSITION.

(… *ame specimen as No. LI.*)

F.	Left frontal sinus.
S.M.I.	Superior middle and inferior turbinated bodie
C.	Catheter in inferior meatus with its tip in Eustachian tube.
T.	Mouth of Eustachian tube.
P.	Soft palate and uvula.
E.	Sphenoidal cell.

STEREOGRAM LIV.—THE EUSTACHIAN CATHETER IN THE NOSE

(*Specimen prepared by Dr. W. K. Hutton.*)

The bulk of the catheter is hidden by the nasal septu the tip being in the tube. The hand holds the catheter w the ring pointing to the eye of the patient.

STEREOGRAM